

# METAL INDUSTRY

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## Electrical Exports

**E**XPORTS by Britain's electrical and allied manufacturing industries continue to make an important contribution to our national economy and to electrical development overseas. In 1957 they reached a new peak of £279 millions, which represented some 8 per cent of our total exports in that year. The electrical export figures do not include electrical equipment which is directly coupled to other engineering plant, and if this is included the total in 1957 would probably have exceeded £300 millions. After allowing for the reduced value of money the volume of our electrical exports has doubled since 1947, and has increased fourfold since 1938.

Impressive as these figures—quoted by Mr. H. J. Beard in an address to the tenth British Electrical Power Convention this week—may seem at first sight, it is a salutary thought that while there has been an overall increase in world electrical exports of 54 per cent over the last five years, Britain's increase was below the average at 28 per cent. In the same period the increase in electrical exports by the United States was not far below the average at 47 per cent while Western Germany, with 183 per cent, had the largest increase. Our lower rate of increase is reflected by the gradual reduction in our share of the world electrical exports from 28.1 per cent in 1952 to 23.2 per cent in 1957. In other words, the increase in our exports has not been sufficient to retain our proportion of the world market, and the substantial increase in Western Germany has been at the expense of this country and other countries including the United States.

World demand for electricity is steadily increasing but we cannot take the growth of our exports for granted. Three major factors which must be taken into consideration are, first, the growth of local manufacture in countries which were formerly among our best markets; secondly, the development of export business by other countries; and thirdly, financial and trading developments such as the creation of the European Common Market. With regard to the effect of local industrialization, experience has shown that the demand for imports of electrical equipment tends to grow more rapidly in industrial than in non-industrial countries and that, therefore, the nature of our exports to these countries will have to change as their development progresses. As long as we maintain our technical progress in order to keep pace with these changes they will, therefore continue as important markets.

Of far greater significance, according to Sir George Nelson at the same conference, is the formation of the European Common Market. If it goes ahead and we are not associated with it through a free trade area or in some similar fashion, we may find ourselves trading under very great handicaps in this most valuable market. Continental manufacturers operating within the common tariff wall with a home market of some 350 million people, might well be able to outstrip us in size and productive capacity and so be able to compete with us in Commonwealth, Asiatic and Latin American markets on more favourable terms. It is not, said Sir George, simply a question of a choice between Europe and the Commonwealth. The old pattern of exchanging British industrial goods for Commonwealth primary products is no longer acceptable; they are producing their own industrial goods and their primary industries are expanding more rapidly than the British market. All factors point to the need for a closer integration of the Commonwealth and European economies. In such an integrated economic association Great Britain would have a leading part to play as financier and as technical and scientific leader.

## Out of the MELTING POT

### Practical Import

QUENCHING a pure metal, and even more so a single crystal of a pure metal, might well appear to the more practically-minded metallurgists, familiar with the heat-treatment of alloys, to be quite a useless undertaking. While, in the case of alloys, quenching from a high temperature serves to retain the phase equilibrium conditions present at that temperature and thereby, with or without subsequent heat-treatment, confer certain desirable properties on the alloys, quenching of a pure metal appears, at first sight, to have no such purpose to serve. In actual fact, however, quenching of a pure metal from an elevated temperature does result in the retention of one of the consequences of the metal being heated to that temperature. At the elevated temperature, the more vigorous thermal agitation of the atoms results in an increase in the number of vacancies in the metal, and quenching of the metal succeeds in retaining this increased number of vacancies. The presence of a larger number of vacancies in the quenched metal has been used to explain certain differences in the mechanical behaviour between quenched and unquenched single crystals of metal. As would have been expected, it is possible to eliminate these supernumerary vacancies, and with them the vacancy hardening of the metal, by a suitable annealing treatment of the quenched crystal. All this, while of interest, might still appear to be only of academic interest. A widening of this interest is, however, likely to follow the recent suggestion that it is the presence of these quenched-in vacancies that makes possible the formation of "zones" in quenched aluminium alloys at room temperature. Hitherto there has been no satisfactory explanation for the speed of the formation of these zones, and for the very low value of the energy of activation involved. It now appears that there is satisfactory experimental evidence for the role of quenched-in vacancies in increasing the rate of diffusion, and in lowering the energy of activation sufficiently to account for the speed with which these zones are formed in the room temperature precipitation process in aluminium alloys.

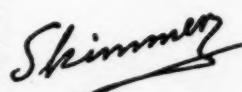
### Towards Agreement

THE assessment of the suitability of sheet metal for deep drawing and related processes has been investigated for a number of years by many organizations in several countries. This statement introduces an announcement of the formation of an International Deep Drawing Research Group for the purpose of exchanging information and co-ordinating further research, and the recent establishment of a British Deep Drawing Research Group to provide a focus for British research and to effect liaison with similar bodies through the International Group. With the above organizations in being, research into deep drawing can thus confidently be expected very soon to get once again into its stride, and again to start yielding the multitudinous results so characteristic of investigations in this field. It should thus very quickly make up for the lost time, i.e. the past few years, during which it has been in abeyance as a result—one could reasonably have thought—of exhaustion of the subject matter, of the investigators, and of those who were expected to digest and ultimately profit by the results. Now, it appears that the investigations that had been carried out for a number

of ( $\simeq$  20 to 30) years had suffered from duplication and lack of co-ordination due to absence of effective contact between the various investigators. Now that the contacts and co-ordination have been organized, it should prove possible to bring testing methods into line and to achieve the *sine qua non* of any successful testing method—consistent results. There will then remain to be seen to what extent these co-ordinated consistent results will correlate with the behaviour of the metal under the unco-ordinated and inconsistent conditions of actual production deep drawing. Indeed, it may well be asked whether the investigations and their results in their former unco-ordinated state, taken together, did not present a truer picture of, and bear a closer relation to, the state of affairs in deep drawing as it exists in practice?

### Measured

ANY general account of the anodizing of aluminium is likely to contain some reference to the solvent action of the anodizing bath on the oxide film. The importance of this action lies in the fact that it largely determines the nature of the film that is obtained. If the film is only slightly soluble in the bath, the thickness to which it can grow will be strictly limited. Intermediate solubilities result in the formation of the relatively thick films used for corrosion protective and decorative purposes. If the electrolyte is very aggressive, the film may dissolve as rapidly as it is formed. Such conditions obtain in the electropolishing or electrobrightening processes. While the above qualitative differences have been known for a long time, there have been few quantitative data on the subject. Some interesting information of this kind has recently been published by two Russian investigators, who studied the rate of solution of the aluminium oxide film in the anodizing of 99.93 per cent aluminium sheet in 10 per cent sulphuric acid. To begin with, dense oxide films were obtained by anodizing for 10 sec. with 4 amp/dm<sup>2</sup> at 20°C. These films were separated from the aluminium by the amalgamation procedure. The rate of solution of the isolated films in the 10 per cent sulphuric acid was then determined at different temperatures. The rate of solution was found to increase logarithmically with the temperature of the acid. The concentration of the acid had much less effect on the rate of solution; a maximum occurred at a concentration of about 20 per cent. Subsequently, the rate of solution of the ordinary porous anodic oxide films in the course of anodizing was determined from the difference between the actual weight of the film and that calculated assuming complete oxidation of the metal by the current. The results agreed with those obtained for the rate of solution by determining the amount of aluminium actually dissolved in the bath. Differences between the rates of solution of these porous films and those of the dense films studied previously, provided a means of evaluating the true surface area (including pores) of the former. It was found that this surface area increases linearly with anodizing time, and it is regarded as constituting the basic factor responsible for the slowing up of the rate of growth of the film. It was also deduced that the temperature of the electrolyte in the pores is higher than that of the bath, and that it falls as anodizing proceeds.



## PROCESSING AND PRODUCTION FOR NUCLEAR APPLICATIONS

## Tantalum, Niobium and Beryllium

By G. L. MILLER, Ph.D., A.R.I.C.

TANTALUM, niobium and beryllium are among the rarer metals which have been the subject of much comment in the last few years. They are all reactive metals, so that they are difficult to produce in a pure state. The present status of these metals is as follows: tantalum (high melting point, high density, excellent corrosion resistance and compatibility with uranium) has been in use for about 50 years and its application has gradually expanded, particularly in the chemical field. The rather rapid recent expansion is due to the development of its use as a capacitor material. Niobium (high melting point, medium density, good corrosion resistance and excellent compatibility with uranium, and high-temperature strength), although available for some years, has only recently become interesting due to its employment as a canning material for the Dounreay reactor and its reported application as an alloying element with uranium for fuel elements. Pure beryllium (low density, lowest neutron absorption cross-section of all metals) has become of considerable interest as a canning material. Its application as a material for reflectors and moderators has been demonstrated. Oddly enough, beryllium appears to be an excellent oxidation-resistant material, and this, combined with its low density, has suggested its use as a structural material for aircraft.

## Chemical Processing

*Tantalum and Niobium.*—The similarity of the chemical properties of these metals complicates their extraction. They occur together in nature and, although niobium was considered to be rather scarce, recent discoveries have shown that the ore supplies are ample for most purposes. Unfortunately, the supplies of high tantalum-containing minerals appears to be running out.

The production of tantalum and niobium metals comprises their extraction from the ore, followed by a purification process aimed chiefly at separation of the tantalum and niobium from each other, followed by reduction and consolidation. There are several methods for decomposition of the ore, but two which have been used on a commercial scale are fusion with caustic soda and solution in hydrofluoric acid. Fusion with caustic soda results in the formation of sodium niobate and tantalate, which can be recovered by digesting the fusion product with water. The insoluble sodium salts of tantalum and niobium are decomposed to the niobic and tantalic acids by treatment with hydro-

chloric acid, which, at the same time, dissolves some of the impurities, and finally the earth acids are dissolved in hydrofluoric acid. If hydrofluoric acid is used to decompose the ore, the tantalum and niobium are dissolved directly.

The ratio of tantalum to niobium in the earth acids will be the same as the ratio of the tantalum to niobium in the ore, and the choice of ore depends upon the purpose for which it is being processed. If tantalum alone is required, then a tantalite with a high tantalum to niobium ratio is most suitable, and if niobium is required, then a columbite with a high niobium to tantalum ratio is treated. Unfortunately, high-grade tantalite ore is very difficult to obtain, and even the tantalite-columbites with a ratio of tantalum to niobium of about 1:1 are becoming difficult. In order to obtain tantalum it is becoming necessary to treat ores which contain more niobium than tantalum. This increases the processing costs, particularly as uses for the niobium have not yet been sufficiently developed.

Tantalum salts, free from niobium, are obtained from hydrofluoric acid solutions of the elements by addition of sufficient potassium fluoride to produce the double fluorides,  $K_2TaF_7$  and  $K_2NbOF_6$ . The tantalum salt, being of much lower solubility than the niobium salt, can be precipitated if the solution is fairly concentrated. Traces of niobium carried down with the tantalum salt are removed by crystallizing from dilute hydrofluoric acid.

This method of separation, known as the Marignac process, has been used for the production of tantalum for about 50 years, and with good ores it worked very well. The production of niobium free from tantalum is much more difficult and, although it has been achieved by conventional chemical methods, it was only done with considerable difficulty. Fortunately, the separation can be achieved much more readily by the use of the relatively new liquid/liquid extraction process, wherein a solvent such as methyl isobutyl ketone is employed to separate the metals.

The separation of tantalum and niobium by a method involving chlorination has been studied by the United Kingdom Atomic Energy Authority. This method provides a relatively simple means of forming pure mixed chlorides: the impurities, such as iron, tin, titanium, aluminium, etc., usually associated with tantalum and niobium are all readily separated because of differences in the boiling point of their

chlorides; tantalum and niobium pentachlorides have little difference in boiling point, but hydrogen reduction of the mixed chlorides at about 500°C. results in the formation of niobium trichloride, which has a much higher boiling point than the unchanged tantalum pentachloride, which can be separated by distillation. The remaining niobium trichloride may then be reduced by hydrogen at a higher temperature (650°C.).

*Beryllium* is obtained from beryl (beryllium aluminium silicate), which occurs in many deposits, only a few of which can be operated because, unless the beryl is large enough to be hand-picked, it cannot be separated from associated minerals such as quartz and feldspar, and other minerals with similar densities. Investigations have been proceeding for some time on methods for concentrating the beryl from fine-grained deposits, but so far successful results have not been announced. No doubt some of the failure to obtain results can be attributed to the fact that it has been possible to buy as much beryl as was required. There are two main processes for the treatment of beryl: (i) roasting with sodium silico fluoride, and (ii) sulphuric acid treatment of the fused mineral. Both processes ultimately yield beryllium hydroxide, which is the basis of the metal production.

In the silico-fluoride process, the crushed beryl is mixed with the sodium silico fluoride and roasted at about 750°-800°C. to form soluble beryllium fluorides. Both the simple fluoride,  $BeF_3$ , and the double salt,  $Na_2BeF_4$ , are formed. The quantity of silico-fluoride used is limited in order to favour the formation of  $BeF_3$ , since this salt is much more soluble than  $Na_2BeF_4$ . The beryllium fluorides are then leached from the calcined material and, after removal of impurities, treated with sodium hydroxide to precipitate beryllium hydroxide.

In the alternative process, the beryl is fused, quenched, and finally heat-treated to ensure that beryllium content is rendered acid-soluble. The powdered material is slurried with sulphuric acid and reacted at 200°-300°C. Afterwards the product is leached with water. The aluminium, which is the major impurity in the solution, is removed by addition of ammonium sulphate to form alum (aluminium ammonium sulphate), which is separated by fractional crystallization. The beryllium, as before, is precipitated by the addition of sodium hydroxide, which forms the insoluble beryllium hydroxide.

Both processes are complicated by the precautions necessary to ensure the safety of the operators from poisoning by toxic beryllium compounds.

### Metal Production

**Tantalum** is generally recovered as potassium tantalum fluoride which, if the processing has been properly controlled, should be a dry, pure crystalline salt. If the crystals have been produced without due care, they will probably contain appreciable amounts of potassium tantalum oxy-fluoride, which would result in high oxygen content in the metal produced from such crystals. Potassium tantalum fluoride can be reduced directly with sodium, the reaction being performed in a steel crucible with the crystals and sodium packed in alternate layers. The reaction is started in one zone and spreads rapidly throughout the whole charge. The product consists of tantalum powder, excess sodium, un-reduced potassium tantalum fluoride, potassium and sodium fluorides. The tantalum is recovered by a complicated leaching process which involves water, hydrochloric and hydrofluoric acids. The final product, the tantalum metal, is comparatively pure, and the residual oxygen, carbon, etc., provided they are not excessive, can be removed during the sintering process. An alternative method is the electrolysis of a fused bath of potassium tantalum fluoride containing potassium fluoride and chloride to which tantalum oxide is added at intervals. Curiously enough, tantalum is not produced by electrolysis of pure potassium tantalum fluoride. The tantalum produced by electrolysis is similar in purity to that obtained by sodium reduction, but quite different in appearance. It is coarse and dense whereas, by comparison, the sodium-reduced metal is fine and porous.

**Niobium** may be produced by both the methods described for tantalum but as the salt, niobium potassium fluoride, so readily reverts to niobium potassium oxy-fluoride, production of the niobium metal by reduction of this salt with sodium is not very satisfactory.

It has been reported by C. W. Balke, of the Fansteel Metallurgical Corporation, that the electrolytic production of niobium was unsatisfactory, particularly as it gave a low metal recovery. Balke preferred to use an entirely different method, i.e. reduction of niobium oxide with niobium carbide. It is interesting to note that von Bolton, who was responsible for so much development in the tantalum field, produced niobium by heating a filament of niobium tetroxide, by direct resistance, in a vacuum. It was stated that the oxygen was evolved in the elemental form, but this is most unlikely. In von Bolton's case, the tetroxide had been formed by heating pentoxide rods in carbon to a white heat, and it may be safely assumed

that the product was a lower oxide of niobium plus niobium carbide, which then reacted when heated *in vacuo* to form niobium and carbon monoxide. It is also possible to remove oxygen from niobium as a volatile lower oxide, and if silicon is present this will remove some oxygen as the volatile silicon monoxide. These remarks also apply to tantalum. The niobium produced at Fansteel Metallurgical Corporation was produced by mixing niobium pentoxide with niobium carbide and heating *in vacuo* to above 1,600°C. The product was a fairly pure metal which still contained residual carbon and oxygen, but, by resintering at a higher temperature *in vacuo*, the residual impurities were substantially eliminated and the metal rendered ductile.

As already mentioned, niobium can be produced by hydrogen reduction of the chloride; the product is a very fine powder.

**Beryllium**.—Two methods are used in industry for the production of beryllium metal: (i) electrolysis of fused salts containing beryllium chloride, and (ii) magnesium reduction of beryllium fluoride.

The chlorination of beryllium oxide would appear to be simple, and the operations manageable, but when one appreciates that the product is extremely hygroscopic (the moisture absorbed resulting in contamination of the metal) and the fumes toxic, it is obvious that there are problems in the design of suitable equipment—particularly as the chlorinators which are used generally require considerable maintenance and tend to become soaked with the chloride.

The electrolyte is a mixture of beryllium chloride and sodium chloride. The resulting beryllium metal is usually in the form of flakes, which have to be recovered from the adhering electrolyte by leaching. This, again, is not so simple as it would appear, as it is difficult to remove all the salts and the product tends to be rather high in oxide. On the other hand, there are problems in the magnesium-fluoride process. The fluoride is formed by dissolving hydroxide in hydrofluoric acid, followed by addition of ammonium fluoride, enabling the double fluoride  $(\text{NH}_4)_2\text{BeF}_4$  to be crystallized. This is decomposed by heat, removing  $\text{NH}_4\text{F}$ , and the residual beryllium fluoride  $\text{BeF}_2$  fused to a glass, which has the advantage that it does not absorb moisture.

The fluoride is then reduced by heating with magnesium in a graphite crucible, beryllium metal and magnesium fluoride being formed. After reduction the temperature is raised to the melting point of the beryllium to form pebbles of metal, which can be separated by wet milling in a stainless steel mill through which solution is pumped continuously to carry away the fine magnesium fluoride particles. The product is a dense powder, relatively low in oxygen (about 0.1 per cent  $\text{BeO}$ ) but containing

appreciable amounts of magnesium and magnesium fluoride (total magnesium up to 1.5 per cent).

### Consolidation of Powders

**Tantalum and Niobium**.—The metal powders produced as described earlier contain impurities such as oxygen, nitrogen and carbon. Provided these impurities are not excessive, and also provided certain precautions are taken, e.g. the carbon present must be approximately equivalent to the oxygen content, as carbon cannot be removed if oxygen is not present to form the carbon monoxide, then these impurities can be eliminated during the sintering operations.

Niobium and tantalum are sintered in the form of bars formed by compacting the metal powders at pressures up to 30-50 tons/in<sup>2</sup>. The bars are heated in a furnace which can be evacuated to a very low pressure. Pumps capable of handling large quantities of gases must be employed, otherwise excessive sintering schedules are necessary to ensure removal of impurities before attaining the full sintering temperature. Usually, the bars are heated directly by passing current through them; alternatively, they may be heated by radiation from a tungsten or tantalum susceptor heated by induction. The latter method is attractive as it ensures that the whole bar is heated to full temperature, whereas this is impossible when the bars are sintered by direct resistance heating, since the ends are secured in water-cooled clamps. Heating by induction through susceptors poses the problem of finding a material that can be used economically for this purpose, as most materials fail after a few operations. During the sintering operation, care is necessary to ensure that the gases are removed before the metal has become too dense to permit ready escape of the gases. Sintering tends to start on the outer surfaces, and it is necessary to ensure that this has not proceeded too far before the impurities are eliminated from the inner zone.

In the case of both tantalum and niobium, the final metal is soft and ductile, but it is generally necessary to forge or roll the sintered bar and resinter for a short period to ensure maximum ductility; this results in further loss of metal, since the cold ends must be removed for a second time.

Arc melting of tantalum has been investigated and it is believed that ingots have been produced. Full details of the properties of the arc melted metal have not been disclosed, nor the method of operation, but it is probable that only pure metal can be melted if the resulting ingot is to exhibit ductility. Arc melting would hardly permit sufficient time for the impurities to be removed, particularly where a reaction is necessary before they become gaseous. Therefore, the virgin powder would not be suitable

for direct arc melting and a pre-treatment for the removal of impurities would be necessary, so that arc melting appears to achieve no reduction in cost over sintering. There are certain characteristics of tantalum that make it a rather difficult metal to arc melt. First of all, its high melting point tends to reduce the burn-off rate and, therefore, decrease the stability of the arc, and this can only be rectified by increasing the current density. Secondly, the partition of power between the electrode and the ingot is such that by far the greater proportion of the heat is concentrated at the ingot. Normally, D.C. is used with the electrode negative, which greatly increases the possibility of puncturing the water-cooled copper crucible when the arc wanders on to the wall.

These remarks also apply, in general, to niobium, but in this case the situation is eased because of the lower melting point. The production of arc melted niobium ingots has been reported.

Information from the U.S.A. indicates that electron-bombardment has been applied to niobium (the first reported operations with niobium were carried out by the U.K. Atomic Energy Authority on a small scale). No details are available, but bars a few ft. long and about 3 in. to 4 in. in diameter have been treated in this manner. The general technique of floating zone melting, where the heat is applied by electron bombardment or by H.F. induction, is an interesting one for application to niobium and tantalum, as it offers the possibility of holding the molten metal in a vacuum, and out of contact with any foreign material, for a much longer time than is possible with consumable electrode arc melting. (Non-consumable electrode melting *in vacuo* is not a practical technique.) It would be interesting to know if this treatment could be applied to a compacted powder bar, when all impurities could be eliminated quickly from the molten metal instead of slowly from the solid by the normal sintering technique.

After consolidation, tantalum and niobium can be fabricated into all conventional forms, such as sheet, foil, seamless tube and wire. It can be deep drawn and spun by modifications of conventional techniques. All operations are performed cold because they are both very reactive and combine readily with oxygen and nitrogen at relatively low temperatures. Annealing, when necessary, must be performed in a very high vacuum (pressures not greater than  $10^{-5}$  mm. Hg must be used). A temperature of 1,350°C. for 1 hr. is satisfactory.

Drawing operations are complicated by the marked tendency of these metals to weld themselves to the walls of dies and tools. A thin oxide film on the surface overcomes the tendency, providing a key for the lubricant used.

Provided precautions are taken to protect the hot metal, both tantalum

and niobium can be welded satisfactorily. For fusion welds the argon arc process is used, taking care to provide protection on both sides of the metal. Resistance seam welding is used and is generally carried out under water, a method which ensures that the hot metal is cooled before contamination can occur.

**Beryllium**, produced by magnesium reduction of beryllium fluoride, contains appreciable quantities of magnesium and magnesium fluoride and, before proceeding further, it is necessary to purify this metal. Purification is best attained by melting the metal in a graphite crucible in a good vacuum, when the magnesium is substantially eliminated.

Beryllium ingots produced by melting beryllium powder, whether electrolytic or magnesium-reduced, do not yield satisfactory fabricated material. Failure to obtain ductility in ingot metal resulted in investigation by powder metallurgical techniques. The most ductile beryllium metal was produced by a method worked out by the Brush Beryllium Company, of America. This method involved the turning of ingots on a lathe to yield metal chips, which were ground to fine powder. Precautions were taken at all stages to prevent oxidation but a little did occur, particularly in the grinding stage, despite the use of inert gas in the mill. The oxygen content of the beryllium powder was about 1 per cent and this increased rapidly if the powder was ground more finely. The particle size and oxygen content of the powder produced by Brush was reckoned to be the best compromise. In any case, the oxygen content of the powder was considered to have an important effect on final ductility by inhibiting grain growth during hot processing.

The most satisfactory method for consolidation of beryllium powder is hot pressing. This operation, carried out in a vacuum with very crude steel dies, has been used to produce massive blocks of metal (up to 750 lb.). Full density can be achieved at a temperature of 1,050°C. at a pressure as low as 75 to 150 lb/in<sup>2</sup>. The time required to attain full density is very long, up to 20 hr. Higher pressures, up to 2,000 lb/in<sup>2</sup> at 1,000° to 1,150°C., permit very rapid hot pressing, while the use of preconsolidated powder and rapid processing time permits operating without atmospheric protection. Finally, the blocks of sintered metal are sawn into sections as required and extruded.

The hot pressed metal showed slight isotropic ductility in tension (2.5 per cent) while material extruded from this metal showed ductility up to 15 per cent in the direction of extrusion, but transverse values were much lower. Beryllium sheet with ductility up to 30 per cent in all directions in the plane of the sheet has been produced (even foil has been made), but the ductility through the sheet was low.

The brittleness of beryllium is a problem which has received very considerable investigation, and progress has been made, not only by laboratory discoveries but also by that knowledge which comes imperceptibly with experience. Yet the material is still unsatisfactory except for purposes not involving appreciable straining, or where thickness of the metal can be used to offset its low strength. The real cause of the low ductility is not really understood, but it is believed by many workers that a gradual improvement in purity, combined with a build-up of experience in handling the metal, will result in a product which will satisfy most demands.

## Metal Market Data

**S**TATISTICS to the layman tend to be held suspect, but to the initiated they are an invaluable aid. Those who know "Metal Statistics" will welcome the 1958 edition, which contains figures for production, consumption, and prices of all the major metals, ferrous and non-ferrous. The figures cover the United States in detail, and world production is also given. For iron, steel, aluminium, copper, zinc, data are given on some of the wrought forms; for most other metals the primary material is dealt with. A comprehensive reference, this book is obtainable from American Metal Market, 18 Cliff Street, New York 38, N.Y., U.S.A., price \$3.50.

Additional material, included for the first time this year, comprises world production of chromite, world production of bauxite, details of U.S. shipments of aluminium foil, with imports from Canada, and some further coke prices.

## Aluminium in Electricity

**I**NCLUDING twelve Papers that were submitted for discussion and further contributions from Italy and the U.S.A., making a total of fourteen, "Symposium on Aluminium and its Alloys in Electrical Engineering" has recently been published by The Aluminium Development Association, 33 Grosvenor Street, London, W.1, price 20s. 0d.

The Papers were discussed in three sessions, dealing with general and economic considerations; with aluminium in transmission and distribution lines, and with the use of the metal in electrical equipment. The discussion to each of the Papers is included in the volume.

The Symposium sprang from the research and development that has been going on in the uses of aluminium and its alloys in electrical engineering, and from the field experience which had been obtained in those uses over a fair number of years.

## Research Progress

# Thermenol Alloys

BY RECORDER

THE discovery of alloys with useful properties has usually been a result of *ad hoc* work or one of those happy combinations of accident and keen observation. The subsequent development and improvement of a basic alloy are often based, however, on an approach making use of existing knowledge gained, perhaps, for quite unconnected and academic purposes. There are clearly some broad guiding principles which can be used in a search for new alloys. Thus, high creep strengths are often conferred by the presence of high melting point transition elements, e.g. molybdenum; oxidation resistance by, for instance, chromium; and high strength: weight ratios are obviously likely to be obtained if light elements, such as aluminium, are present in substantial quantities.

### Ductility

Perhaps the most common defect found in alloys investigated in such a research programme is a lack of adequate ductility in the material. The growing use of raw materials of increased purity, and of methods of making up the alloys under conditions tending to minimize or even reduce contamination, has shown that in very many instances brittleness is caused by the presence of impurities. A large number of the results of earlier investigations on alloy systems may, therefore, be misleading, though it is somewhat problematical whether repetition of this work, using refined techniques, would repay the effort involved. An indication that it might is provided by a re-examination of iron-aluminium base alloys conducted by the U.S. Naval Ordnance Laboratory and described by J. F. Nachman and W. J. Buehler.<sup>1</sup>

It was known that such alloys containing 10-20 per cent aluminium possessed excellent oxidation resistance and were strong. On the other hand, they were brittle and very difficult to fabricate on this account. Ternary additions did not appear to give any appreciable benefits.

Nachman and Buehler first made a study of the effects of melting methods and conditions on the properties of such alloys. They showed that some ductility could be obtained if precautions were taken to prevent contamination occurring and reducing conditions maintained. The most convenient method was found to be induction melting using either a hydrogen atmosphere (followed by helium for the pouring stage) or vacuum. In the latter case, the melt is kept in contact with carbon—some pick-up of this

element not being particularly detrimental except when special magnetic properties are required.

The most interesting ternary alloys developed contained between 10 and 18 per cent aluminium and 2 to 4 per cent molybdenum. These "Thermenol" materials could be readily hot worked at temperatures of 950°C. or over. After initial breaking down, subsequent reductions could be imposed at lower temperatures, and there was a slight improvement in room temperature properties if this working was carried out in a rather narrow range round 575°C.

Although the fabrication problem appeared to be overcome by attention to the purity of the alloys, the room temperature ductility was undesirably low. Thus, in a typical material of the iron-aluminium-molybdenum series only 2-3 per cent elongation could generally be obtained, though values of up to 6 per cent or so were measured in exceptional instances. As-annealed, the tensile strength varied considerably, but seldom fell below 31 tons/in<sup>2</sup>. By cold rolling, this could be increased to over 50 tons/in<sup>2</sup> but, as would be expected, the ductility was impaired, seldom exceeding 1 per cent in cold rolled sheet. It was found, however, that at elevated temperatures excellent combinations of properties could be obtained, since although at temperatures up to about 250°C. slight decreases in strength and increases in elongation occurred, ultimate tensile values exceeding the room temperature figures were given in the range 300-525°C., the ductility improving markedly, particularly above about 400°C. The retention of strength, combined with the relatively low density of the alloys (6.58 gm./c.c. for material containing 16 per cent aluminium and 3.3 per cent molybdenum) thus gave good strength:weight ratios and, indeed, the authors claim that above 230°C. the alloys are superior in this respect to the precipitation-hardening steels much discussed for structural applications in this temperature range.

As is so often the case in American work, however, too much reliance appears to have been placed on elevated temperature tensile tests, which are known not always to give an accurate indication of creep properties. In a subsequent Paper,<sup>2</sup> some data are presented by Buehler and C. G. Dalrymple which show that a 100 hr. rupture life at 650°C. is obtained at a stress of approximately 11 tons/in<sup>2</sup>, a value high enough to suggest that the creep performance might indeed be good.

The increase in both strength and ductility at elevated temperatures is attributed by Nachman and Buehler to an order-disorder transformation occurring in the body-centred cubic alloy. This feature may also explain several anomalous results which they obtained which appear to be connected with the fabricating and heat-treatment conditions associated with the various samples.

### Oxidation Resistance

The resistance of the material to attack under oxidizing conditions was not apparently impaired by the ternary addition. In air, the surface deteriorated at a rate of only 0.0003 in./year at 1,200°C., and exposures of several hours at 1,375°C. caused "no perceptible damage." The presence of vanadium in the atmosphere increased attack considerably, though the rate of oxidation at 875°C. was markedly less than that of a 25-20 chromium-nickel stainless steel under similar conditions. Corrosion resistance was also high in other reactive media, e.g. fuming nitric acid, sodium hydroxide solutions, boiling magnesium chloride solutions, edible juices, and so on. The most serious deterioration was found in hydrochloric acid and, particularly, ferric chloride solutions. The relevance of the tests mentioned above on the effects of vanadium-bearing atmospheres is a little obscure, since the rapid decrease in strength at temperatures above about 650°C. makes it unlikely that the alloys could be used for turbine blades.

### Grain Growth

The range of interesting properties shown by the alloys clearly justified further work on the system to determine whether the low room temperature ductility could be improved. Another undesirable effect, also giving rise to some difficulties, was the tendency for rapid grain growth to occur in the material above the recrystallization temperature (750°C.). Buehler and Dalrymple describe the improvement brought about by additions to the basic iron-aluminium-molybdenum alloy of carbon (0.05-0.10 per cent) plus zirconium (0.2-0.4 per cent). It was found that the properties of this modified material were influenced by heat-treatment, the optimum values being obtained by procedures giving the smallest possible grain size (recrystallized) and the greatest degree of structural disorder. The latter condition was met by quenching from

(Continued on page 516)

## Pressure Die-Casting Review

# Die-Cast Record Changer

REFERENCE was made in an earlier article (METAL INDUSTRY, 23 May, 1958, p. 429) to the exacting demands made by current standards of high fidelity reproduction on the mechanical efficiency, dimensional accuracy and rigidity of tape recorders and record changers. Superlative "hi-fi" equipment is necessarily too expensive to reach a tremendously wide market, yet the very high standards of production achieved by Collaro Limited enable them to produce a high-grade record player for high fidelity systems, in which many of the components are pressure die-castings and come from the same basic production pattern as those used in their more popular and inexpensive models. This dual role of the die-cast components arises partly from their inherent high quality and in part from the very high standards which Collaro

maintain for their normal production models.

In the high quality equipment, certain refinements, such as a heavy die-cast turntable, are incorporated but, fundamentally, the "Transcription" model, which is intended for highly-critical audiences, differs little from the standard "Conquest" record changer which goes into hundreds of

thousands of instruments selling at popular prices. Like more expensive equipment, the latter has a four-speed drive mechanism incorporating a solidly constructed motor with a dynamically-balanced rotor. Every rotor is carefully checked and any out-of-balance corrected to bring it within very close tolerances.

It is this attention to individual

Fig. 1—Upper side of the die-cast 'cam gear of the "Conquest" record changer

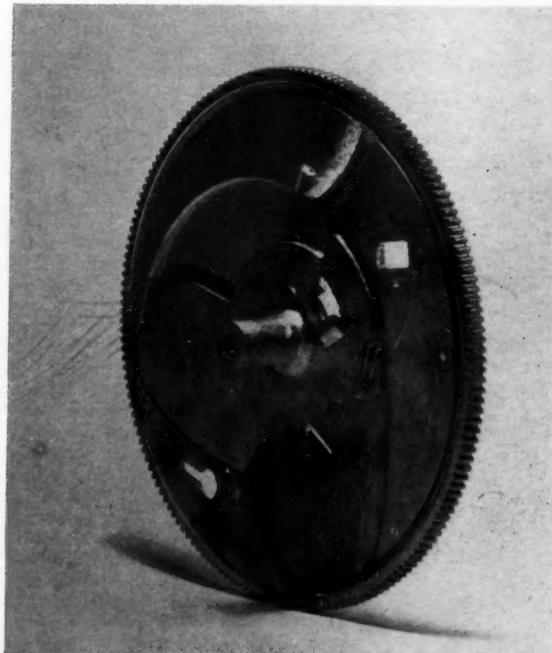
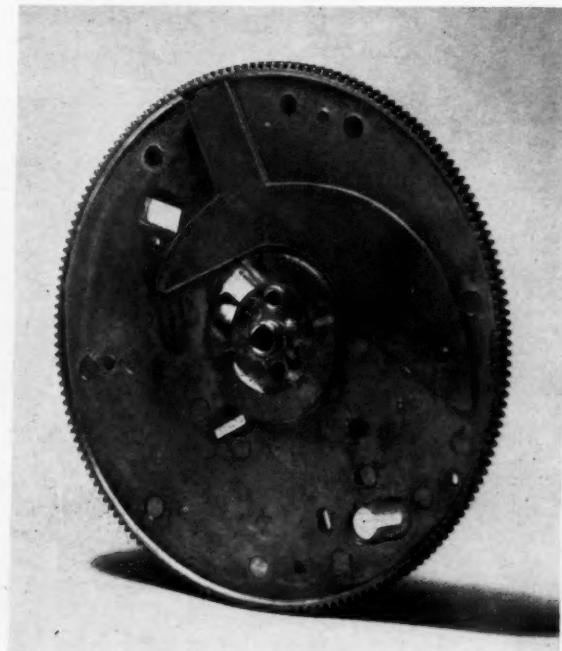


Fig. 2—Under side of the cam gear, showing the cored holes of various sizes and shapes



The Collaro "Conquest" record changer

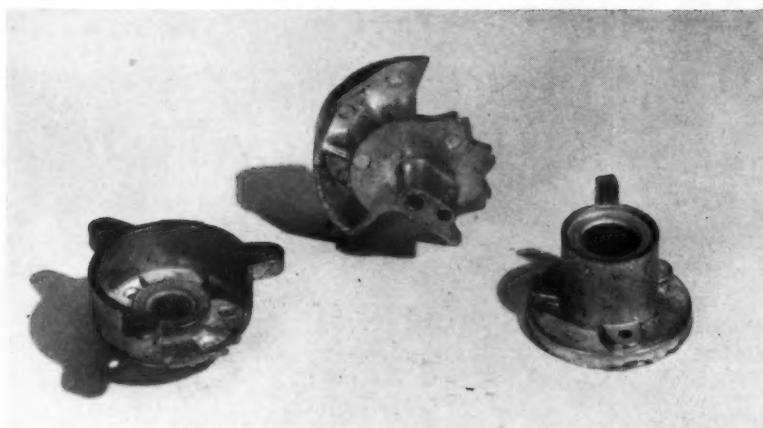


Fig. 3—The turntable spigot housing, 4-speed cam and turntable boss

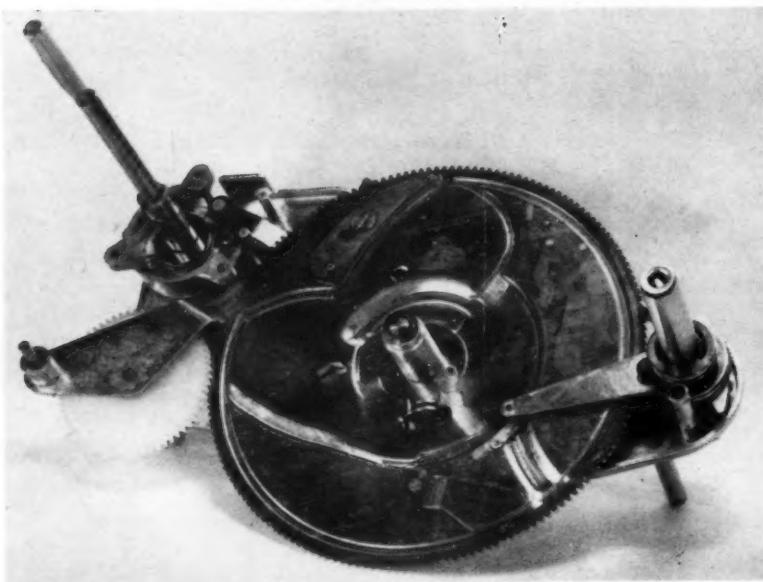


Fig. 4—The complete sub-plate assembly, showing the cam gear and turntable spigot housing in their relative positions

Fig. 5—The pick-up arm swivel bracket, balancing arm column, cantilever, pick-up arm pivot housing and the counterweight



instruments and their adjustment that ensures high-quality performance, just as it is the wide use of pressure die-castings that has made possible the fast and economical production of many of the components. Several of these components have intrinsic interest as die-castings and will be described here.

Those responsible for publicizing and furthering the adoption of pressure die-castings have made much of the ability of this process to reproduce accurately such details as cam forms and gear teeth, thus eliminating much of the costly machining that has been associated with other forms of production. The casting shown in Figs. 1 and 2 is an excellent example of the possibilities of die-casting for this purpose. This cam gear, the largest casting in the record changer, has a diameter of  $5\frac{3}{4}$  in., gear teeth being incorporated around the entire perimeter. On its upper face a series of cam grooves are cast in; these cams provide the control for the pick-up arm and the automatic change mechanism. In addition to the cam grooves, a number of apertures are cored through the face to provide locations or fixing points for some of the parts that are assembled on to it.

With a component of this kind, it is not difficult to see the benefits that accrue from the use of die-casting. In providing the gear teeth alone, true to form and needing no machining other than a light facing operation to remove flash, the pressure die-casting more than compensates for any less favourable features, such as high die cost, that it may entail. Add to this saving of machining the economies arising from the cast-in cam form, the provision of bosses and pads, and no metal lost as swarf or scrap, and it will be at once recognized that for this type of component there is no other mode of production that could be considered. Even further economies are recognizable when handling times are thought of; how many times would this component return to floor if its various features had to be machined?

It is true, of course, that die cost for a component like this would be high, and this fact often tends to turn manufacturers and designers from adopting die-castings for anything but high production quantities. There is, however, no optimum production figure at which any given component becomes a sound die-casting proposition. So much depends upon floor space, handling methods, availability of machine tools, finish required, and so on. All these factors influence the economies of a specific production programme, and one manufacturer, finding his machining capacity fully occupied, may well see savings in a die-casting running 3,000-5,000 a year, while another firm would only find it worth while to turn over to die-casting if a production of 30,000-40,000 a year were envisaged.

In Fig. 2, the underside of the cam

gear is shown, and this side also emphasizes what has previously been said of the advantages of die-casting.

The three castings in Fig. 3 are the turntable spigot housing, the turntable boss, and the four-speed cam. Of these, the first two mentioned are relatively simple flanged bosses, with cored fixing holes, cast-in lugs and a central bore. The four-speed cam is rather more complex and includes a flange with three switch positions, an elongated boss, and a platform along the edge of which are cast four steps. These, in turn, raise the idler assembly into position against a four cone pulley on the motor spindle, thus providing the drive for the turntable at the chosen speed.

The complete sub-plate assembly, with the cam gear and other castings, is shown in Fig. 4.

The balancing arm and pick-up arm assemblies also use a number of

pressure die-castings, and these are shown in Fig. 5. The tall pillar is the balancing arm column, and upon this is mounted the arm that lies across and keeps level the pile of records when using the auto-changer. It has a cam slot in its upper end, in which the balancing arm rests when it is not over the turntable spindle. Cored through the centre, it has three blind holes in its base, cored out to tapping size for fixing screws.

The pick-up arm pivot housing is a somewhat similar column with two long cored bosses projecting from its flange. Beneath this flange is assembled much of the complex assembly which transmits the operating motions to the pick-up arm.

The remaining castings in Fig. 5 are the counterweight, a heavy casting with a single cored hole and cast-in location for a hexagon nut, the cantilever, and the pick-up arm swivel

bracket. The last-mentioned has four cast-in dogs at the extremities of the arm, a small cored lug alongside the main boss, and an aperture through the main boss that has three sides at right angles and two more obtuse.

Common to both the "Conquest" record changers and the tape transcription unit are the die-castings that are used in the motor. These were illustrated in the article referred to earlier.

Even these miscellaneous components, relatively simple though they are, exhibit features which make them especially suitable for production as die-castings. They are, of course, produced in very high quantities, for the output at Collaro is astonishing, and there are few countries to which their products are not sold. Even the U.S.A., the home, one would think, of sound reproduction equipment, provides a large market for these record changers.

## Men and Metals

In the Birthday Honours List, published last week, the C.B.E. has been awarded to **Mr. Evan Ag. Norton**, chairman of the British Rollmakers' Corporation, chairman of Charles Clifford Limited and of Metallisation Limited, and a director of Hall Street Metal Rolling Company Limited.

The O.B.E. was awarded to **Mr. J. T. Fallon**, chairman of the Incandescent Heat group of companies. Mr. Fallon is a Justice of the Peace, and is also a Past-President of the Birmingham Metallurgical Society.

The M.B.E. was awarded to **Mr. W. H. Hodgetts**, production manager of the Copper Products Group of Imperial Chemical Industries Limited.

Two new executives have recently been appointed by Tiltman Langley

Limited, of Redhill Aerodrome, South Nutfield, Surrey. **Mr. J. C. Stevenson**, B.Sc., F.R.Ae.S., has been appointed chief technician, and **Mr. E. F. Maillard**, B.Sc., A.R.I.C., A.I.M., has been appointed metallurgist. Mr. Stevenson was educated at Glasgow University, where he gained an honours degree (Eng.), followed by a post-graduate year in aeronautical research as first Busk Research Scholar. Mr. Maillard was educated at London University, and spent some years at Essex Aero Limited as chief metallurgist and chemist. Since 1955 he has been with the English Electric Company Limited, giving advice on the properties of metallic and non-metallic materials at high and low temperatures, and in controlling the quality of the actual materials used.

It was announced at the annual general meeting of the A.P.V. Company Limited that **Dr. R. J. S. Seligman** has resigned his position as chairman of the company but will continue with the company as President. **Mr. William E. Jenkins**, C.B.E., is to succeed Dr. Seligman as chairman.

It is learned from The British Non-Ferrous Metals Research Association that **Dr. W. A. Baker**, research manager of the association, is leaving that position at the end of next month to join the Northern Aluminium Company Limited. Going to the association in 1935, Dr. Baker acquired an international reputation for his work on the casting of bronzes and of aluminium and magnesium alloys. He became senior metallurgist in 1946 and research manager in 1950. To fill the vacancy arising from Dr. Baker's resignation, the association has appointed **Mr. A. Cibula** and **Mr. R. Eborall**—respectively heads of the melting and casting and of the general metallurgy sections—as research superintendents, jointly responsible to the director for the work of the research department.

## Chemical Pre-Treatment

**UNAFFECTED** by climatic conditions, a new pretreatment for metals, especially aluminium and its alloys, and zinc or zinc-coated surfaces, has been introduced by Jenolite Ltd., 13-17 Rathbone Street, London, W.1, under the name "Jenocote." This application can be brush applied, and is unaffected by most solvents used in paint formulations. On descaled, derusted, or even lightly rusted steel it provides good corrosion resistance. Stoving enamels, cellulose, bituminous epoxy and most other coatings have been used successfully over it to provide additional protection.



Mr. J. T. Fallon



Mr. J. C. Stevenson

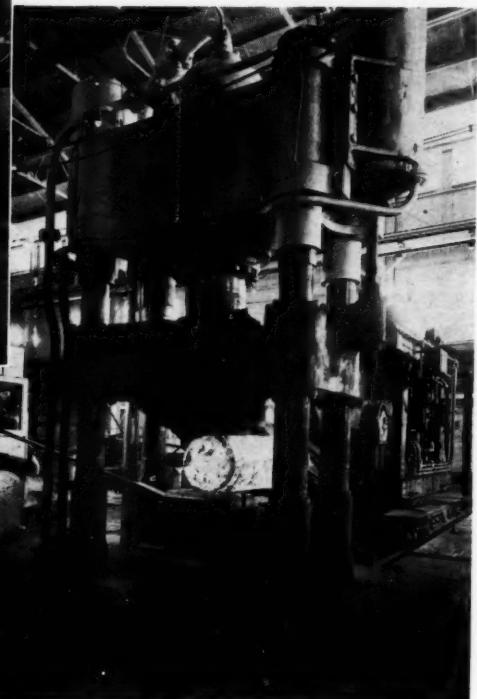


Mr. W. H. Hodgetts



Mr. E. F. Maillard

## TITANIUM IN TORONTO



Top left : Removing a 26 in. diameter billet from the furnace

Above : Forging a 5,200 lb. titanium billet



Centre left : Grinding the surface of forged billets. The grinder moves along a line of billets. In the background is the dust collection system

Left : One of the large lathes for turning titanium bar

SOME months ago, an entirely new plant was opened in Toronto, Canada, by The Titanium Metals Corporation of America, and these pictures show some of the fabricating processes. The plant is intended for the rolling and forging of titanium.

Among the specialized features of this plant are specially-designed furnaces, furnace charging equipment, temperature control equipment for billet heating, dust control systems of an unusual character, very large grinding machines for scalping billets, and a number of large lathes.

The plant has been laid down as a result of expected increases in the demand for large bar, rod and strip, arising from the use of the metal in missiles, aircraft and civilian applications.

## INFORMAL DISCUSSION ON PRACTICE OF COMPACTING AND SINTERING

## Developments in Powder Metallurgy

(Continued from METAL INDUSTRY, 13 June, 1958)

At the afternoon session of the informal discussion on "Developments in the Practice of Compacting and Sintering," which was organized by the Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals, **Mr. D. A. Oliver** was in the chair.

The following Papers were presented and jointly discussed: "Developments in Vacuum Sintering Furnaces," by **M. Donovan** (The General Electric Co. Ltd. Research Laboratories, Wembley); "Conditions for Effective Vacuum Sintering and their Realisation in Practice," by **Dr. Otto Winkler** (Geraetebau - Anstalt, Balzers, Fuerstentum, Liechtenstein); "The Pressureless Sintering of Loose Beryllium Powder," by **T. R. Barrett, G. C. Ellis** and **R. A. Knight** (Atomic Weapons Research Establishment, Aldermaston); "Zone Sintering," by **J. Antill** and **M. Gardner** (Atomic Energy Research Establishment, Harwell).

## DISCUSSION

**P. J. Ridout** (Metal and Plastic Compacts Ltd, Birmingham):

Using vacuum sintering in place of more conventional methods in order to achieve improved physical properties would mean vacuum sintering furnaces of quite high capacities. What degree of temperature control would Donovan expect in a furnace of this capacity, where one is controlling the size change of components on a strict time-temperature basis, bearing in mind that the time, for economic reasons, must be comparatively short? In the conventional sintering furnace, a thin layer of components passes through a hot zone at a controlled rate, so that all the components experience the same degree of heating. With vacuum heating in large batches, would the mass of components still be over-size when the outer layers contracted to the correct degree? Does the author consider that there is any possibility of a continuous vacuum sintering furnace being developed in the future?

Regarding the Paper on "The Pressureless Sintering of Loose Beryllium Powder," the very low iron pick-up shown in the analysis of the beryllium powder is surprising. Since it would appear that ball milling is rather a critical factor, have any wet milling techniques been considered, and, if so, what would be the effect on sintering? Due to the slight reaction between the mould and the powder, is it possible to use the graphite moulds more than once, or is it necessary to use new moulds each time?

The Paper on "zone sintering" deals with what appears to be a very impressive development, and one which could make the production of long rods from metal powders a commercial reality. Is there a limiting amount of shrinkage which can be tolerated, in view of the

cracking which the authors experienced due to the stress set up between the sintered and unsintered material, or do the authors consider that successive passes of the furnace over the material at increasing temperatures would overcome any difficulty liable to be experienced in this connection? Lastly, do the authors consider that zone sintering would be practicable for the production of long metal tubes?

**G. T. Moors** (Metropolitan-Vickers):

The principal factor involved in flash-over in high-frequency induction vacuum furnaces is coil voltage; frequency has little direct effect within the range most useful in vacuum sintering furnaces, that is, from 2 to 10 kc/s, but has an indirect effect, in so far as high frequencies require higher coil voltages. Within this frequency range a maximum coil voltage of 300 gives a reasonable safety margin. In our experience flash-over occurs most frequently between coil and furnace body. Voltages approximately twice as high can be used if the coil is earthed at the central point, but in this case attention must be paid to layout and insulation of the power leads-in across which the full voltage is applied. Insulation of the coil with several layers of glass or silica tape, and the avoidance of any exposed sharp points, also help.

In choosing between induction and resistance heating, a number of factors are worth considering. Resistance furnaces require their own transformer equipment. In induction furnaces the coil itself is the means of transforming the supply. High-temperature resistance-heating ovens are subject to breakdown due to their brittleness and susceptibility to accident; the induction coil, on the other hand, is robust. The high-frequency supply is extremely adaptable. In our laboratories a 10 kc/s supply has been used for heating to temperatures approaching 3,000°C. in graphite and over 2,000°C. in molybdenum, for hot pressing in moulds from 2 in. diameter to 16 in. diameter, for sintering in crucibles up to 14 in. inside diameter, for melting and gassing furnaces, for brazing of tipped tools, and many other jobs. High-frequency motor generator sets are available from which two independent supplies can be taken. A multi-generator set of this kind is, therefore, suitable for an installation of two, four, six, or more furnaces, according to the time for which each furnace will be connected to the power supply. In the high-frequency induction furnace the thermal stress on refractories is less than in resistance furnaces at the same temperatures. In the induction furnace the refractories are at a lower temperature than the charge; in resistance furnaces the reverse applies.

With regard to vacuum pumps, it is not considered that pump down-time is a relevant factor in choosing a pump. Pumps large enough to cope with the gases evolved during sintering operations are usually more than adequate to deal with pumping down. If powders are present in the furnace as charge or as packing materials, pumping down must be reasonably slow, and it is usually

necessary to pump down through a partially closed valve during this time.

A simple method of vacuum control during sintering operations is to use an electromagnetic valve operated by a vacuum relay. For sintering in high vacuum at temperatures of 2,000°C. and above in a carbon-free atmosphere, resistance furnaces have an advantage over induction furnaces in that radiation screens do not have to be used. Screen materials for these temperatures are molybdenum, tantalum and tungsten. Molybdenum is the most readily volatilized at high temperatures, and tantalum is the most expensive, but both these materials can be obtained in fairly thick sheets with a mirror finish. Tungsten, though suitable for the highest temperatures, cannot be obtained in equal thicknesses with a mirror finish.

On the section of Dr. Winkler's Paper dealing with re-evaporation, how would he ensure that surfaces next to the sintering material are kept at a sufficiently low temperature to prevent re-evaporation? Would he not consider that a vacuum test before the operation of the furnace would be a suitable way of checking the leak rate on the furnace? Has he any experience of the removal of oxygen from molten copper in vacuum? He refers to the removal of oxygen from copper at temperatures around 1,000°C.

Turning to the Paper by Barrett, Ellis and Knight, what is the purpose of the alumina coating on graphite cores, how is it applied, and is the type of graphite used important? Although this Paper deals with pressureless sintering, the application of a certain amount of pressure would not, perhaps, be a disadvantage. Would it be possible to apply a small amount of pressure by utilizing the thermal expansion of the refractory metal bar?

In the Paper by Antill and Gardner on zone sintering, mention is made of the difficulty of sintering in this way materials which have a low green strength. Would it be feasible to use wax or some other volatile bond in order to increase the green strength?

**Dr. P. R. Marshall** (Metal and Plastic Compacts):

In practice, pressing metal powder always involves lubricants, and it seems essential to remove the lubricant, possibly by preliminary heat-treatment, before the work can be treated in vacuum. Dr. Winkler refers to chemisorption, but makes it clear that he is dealing, not with chemisorption, but with either van der Waals' adsorption or activated adsorption. Chemisorption is characterized by the fact that the adsorbed substance can be removed only by chemical reaction.

Dr. Winkler mentions the impossibility of reducing copper oxide by heating it in vacuum. Langmuir himself mentions that if carbon monoxide sits down on a tungsten surface we have a monolayer of CO; this can be pumped off by pressure, but it comes off not as CO but as a compound, WCO. Would that be classed as chemisorption? It is certainly a chemisorbed state.

**J. S. Jackson (B.T.H. Ltd., Rugby):**

As Ridout has indicated, there will, in all probability, be a very great expansion of vacuum sintering, probably into fields in which gaseous sintering has normally been the standard practice, and several additional factors come into the picture.

First, there is the usual question of cost. Here, the extra expense of the vacuum equipment will have to be borne in mind. Then there is the difference in pressing equipment between the two systems, vacuum sintering being essentially a batch process. That at once brings into consideration the question of throughput, and here arises the problem of increasing the size of a given batch while at the same time having the entire contents of the vacuum chamber under accurate temperature and pressure control. The very fact that it is desired to get as much material as possible into the vacuum chamber brings into prominence the question of temperature uniformity. Since a vacuum is being dealt with, there is no gas to diffuse throughout the charge to even out any temperature differences. We have to rely entirely on conduction or radiation.

The question of the time-temperature cycle also comes very much into the picture. In the case of normal gaseous sintering, although only a relatively small amount of material may be in the furnace at any given time, because of the continuous nature of the process quite a high capacity can be realized. In the vacuum system, allowance must be made for the pumping-down time, out-gassing, sintering time, and cooling. Once again, since no gas is present, cooling will take much longer, unless a gas is introduced.

The problem of maintaining a suitable equilibrium between the atmosphere created during sintering and the charge may, in certain circumstances, be quite formidable. Moreover, the efficiency of heating depends, as Donovan has indicated, very much on the radiation shields or refractories. He mentioned the use of lamp-black. This has always seemed to me to be a particularly unsuitable material in every respect, except for its thermal conductivity. It is most inconvenient to handle, and it is by no means unknown for sudden outbursts of gas to occur during the outgassing period, which have the effect of covering everything with a deposit of lamp-black.

**A speaker:**

Can the authors give some indication of the operating pressure during the actual pressureless sintering, and some idea of the extent to which they reduce the metal loss by overlaying the compact with beryllium? Next, they talk about the superficial reaction between the powder and the graphite mould. Just what does this mean? Can some indication be given of yields of some specific size? Are there advantages in using a slightly pre-compacted charge? Have they looked into this? Would this not cut down the sintering time and thus have an economic advantage, and reduce the actual interaction, which would again have an economic advantage?

No mention is made of other mould materials. The standard mould material in American operations with this very high temperature pressing is mild steel. They use a graphite mould with a mild steel liner, and press in that. Presumably there are advantages to be gained in that way.

**Dr. Eudier:**

What does Donovan take as the total input to the furnace? The easiest quan-

tit to measure seems to be the quantity of power which is necessary to heat the molybdenum wire to a certain temperature.

What does Dr. Winkler mean by saying that the dissociation pressure for  $\text{FeO}$  is about  $10^{-15}$  mm. Hg. This, presumably, is the correct theoretical value, but it is not necessary for sintering to have this extremely low pressure. When any metal is heated under vacuum it is first oxidized and after a time almost the total pressure consists of the metal vapour pressure. When the metal cools, every molecule of oxide is deposited against the wall of the furnace by adsorption during cooling, so that finally for sintering a pressure of  $10^{-3}$  mm. Hg. is very often sufficient, even for titanium, because one can very easily have a pressure of  $10^{-3}$  mm. Hg. of titanium vapour.

With regard to the absorption of moisture by bricks or refractories, a temperature of  $800^\circ\text{C}$ . is necessary to remove the moisture of any refractory, so that vacuum furnaces in which the refractories are likely to be affected in this way are extremely difficult to operate unless the process is continuous.

**J. Williams (A.E.R.E., Harwell):**

Regarding pressureless sintering, we were first forced to use the sintering of loose powder at Harwell when work was started on the powder metallurgy of uranium in 1949. The powder as received had a very high pack density, and so it was poured and sintered. The work was reported in three Papers but, unfortunately, they were all classified until about the middle of 1957.

As a result of success with uranium, the people who were concerned with beryllium at the time repeated this work with the beryllium of what the Aldermaston workers called a commercial type, which was, it is believed, a Brush beryllium powder. This sintered quite well, and 98 per cent of the theoretical density was obtained after 5 hr. at  $1,200^\circ\text{C}$ , which ties in well with the results which the present authors report; but the high-temperature properties of this material were such as to limit its interest. This is still the case so far as the strength properties are concerned, but not with regard to the ductility of the material. This is probably due to the fact that in the very early days the importance was not realized of the removal of the first 0.01 in. of beryllium from the machined surface in promoting the ductility of beryllium in the test.

The authors mention that they were able to obtain good quality powder from scrap beryllium containing 1.5 per cent iron. It is not known whether they blended this material or not, but, if it was used neat, it is a little unfair to compare the sintering properties of this material with those of the pure material, because there would almost certainly be a liquid phase present at the sintering temperatures used.

With regard to their point about the small amount of contamination when ball milling the powder with stainless steel mills and balls, after putting the first few charges of beryllium into a mill of this description we found that, although there is an appreciable iron pick-up for the first two runs, the mill and balls seem to be covered with a layer of beryllium and there is very little iron pick-up.

On the use of wet milling, our experience has been that it is necessary to be extremely careful, particularly with the very pure flake beryllium powder, which

will pick up oxygen in the form of hydroxide very readily from water at temperatures as low as  $60^\circ\text{C}$ . When continually forming fresh surfaces, as in ball milling, the reaction of a fresh surface must be considerably higher than that of a contaminated surface.

Turning to the use of alumina as a mould dressing, have the authors observed any pick-up of aluminium? Beryllium will react with alumina at these temperatures and reduce it.

On the question of fuel elements and the sintering of beryllium with an oxide core, it is necessary to be careful about what is said about the interaction of these two materials. If the results which the authors obtained were on the uranium oxide compacts supplied by us I feel a little guilty, because the oxide supplied was non-stoichiometric oxide, and there is a world of difference between the reaction of beryllium with a non-stoichiometric oxide and its reaction with a stoichiometric oxide.

So far as the properties of sintered beryllium are concerned, the authors may not be aware of a recent Paper published on the effect of grain size on the mechanical properties of the so-called two-way ductile beryllium sheet. This reports a remarkable decrease in strength and ductility of such material as the grain size increases. I think the figures are 20 tons/in<sup>2</sup> and 7 per cent elongation for such sheet made from the unsintered beryllium, but for similar sheet prepared from finer grain materials the figures are 30 tons/in<sup>2</sup> and 25 per cent elongation.

(To be continued)

**Research Progress**

—continued from page 510

above the order-disorder transformation temperature ( $625^\circ\text{C}$ ). Examples of the properties so obtained are given and show marked improvements compared with the ternary alloy. Thus, a material containing 0.2 per cent zirconium, 0.05 per cent carbon, warm-worked to a reduction of 84 per cent, had an ultimate tensile strength of nearly 58 tons/in<sup>2</sup> and an elongation of 10.5 per cent when quenched after 1 hr. at  $725^\circ\text{C}$ . The tendency for excessive grain growth to occur at elevated temperatures was also reduced considerably and was acceptably low, certainly up to about  $1,100^\circ\text{C}$ . Unfortunately, no details are given of the effect of the minor additions on the elevated temperature properties, though it may, perhaps, be assumed that these should be enhanced rather than reduced. It seems probable that further improvements should be possible in this particular alloy series, but the publication of more detailed results of the recent experimental work must be awaited before a reliable assessment of the likely value of the materials can be made.

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1. J. F. Nachman and W. J. Buehler; U.S. Naval Ordnance Laboratory Report 4237, PB121098, May, 1956.
2. W. J. Buehler and C. G. Dalrymple; *Met. Prog.*, 1958, **73** (5), 78.

# Industrial News

## Home and Overseas

### An Acquisition

We are informed by **Roto-Finish Ltd.** that they have acquired from **Jacquet-Hispano Suiza, S.A.**, the controlling interest in **Modern Electrolytic Patents and Processes Ltd.**, specialists in the electropolishing of metals.

**M.E.P.P. Ltd.** was formed in 1948 for the purpose of developing the industrial applications of electrolytic polishing and chemical brightening. The company was granted an exclusive licence for the U.K. and British Commonwealth in respect of all metal finishing processes held by the Battelle Development Corporation, U.S.A., and by the **Jacquet-Hispano Suiza** group in France. The processes were covered by world patents and **M.E.P.P.** acquired a portfolio of over 25 British, Australian and South African patents. More recently the company acquired the exclusive rights for the U.K. and Commonwealth for the processes developed by **Elektrolyse Gesellschaft m.b.H.** of Munich.

There is to be the closest technical liaison between **Roto-Finish Ltd.** and **M.E.P.P. Ltd.**, and a joint service will be available to determine the most suitable and economical process for deburring or polishing components.

### A Commemorative Medallion

In order to commemorate the first production of aluminium ingot at their Baie Comeau smelter, the **Canadian British Aluminium Company**, a subsidiary of the British Aluminium Company Ltd., formed in partnership with the Quebec North Shore Paper Company, have issued a medallion, made of aluminium. This medallion was designed by the Design Research Unit and produced by **J. R. Gaunt** and **Son Ltd.**, of Birmingham.

The company's new smelter is situated on the north shore of the St. Lawrence River, 400 miles north-east of Montreal. Less than 20 months after work commenced on the site, the first metal was poured there in December last year. These first ingots were then sent to Britain and from them the sheet for the medallions was rolled at the Milton, Staffordshire, works of the British Aluminium Co. Ltd.

The obverse of the medallion records in French the fact that it was produced from the first ingots from the smelter. The design of the reverse represents the essential features of the country in which the smelter is situated—rock, trees and water—and the conversion of the water into power for aluminium production is symbolized by a pylon. The medallions were distributed to guests, employees and members of companies associated with the construction of the smelter on the occasion of the official opening by **Mr. du Plessis**, Premier of Quebec, on Saturday last.

### A "25" Club

A duck supper at a Warwickshire country pub was the first social occasion arranged for members of the newly-formed "25" club for employees of the **Aston Chain and Hook Company Ltd.**, Birmingham. Membership of the club is confined to those who have completed a quarter of a century or more with the company, and the aggregate length of

service of the 31 founder-members totals 1,120 years—an average of more than 36 years each. The senior member is Mr. Alfred Such, chain machine setter-operator, who has completed 50 years with the company.

Neat blue enamel and silver badges were presented to the "Twenty-Fivers," who in return sprang a surprise on their managing director, Mr. Noel Bond-Williams (who has a further three years to do before qualifying), presenting him with a yachtsman's stop-watch. Other non-member guests were the **Hon. John Grimston**, chairman of Enfield Rolling Mills Ltd., the parent company, and **Mr. Clifford Atkins**, a director of the Aston company.

### A Manchester Depot

Owing to the increased use of "Silver-crown" electroplating chemicals and equipment in the north-western area, **Silvercrown Limited** have opened a depot at South Road, Trafford Park, Manchester 17, with the telephone number Trafford Park 0401.

Maintenance additions for the "Supersonic" range of fast and bright plating solutions, as well as most items required in the day-to-day running of a plating shop will be held in stock, and prompt deliveries in the north-western area can be given.

### Award-Winning Film

Scenes showing impact extrusion and aluminium foil rolling at Venesta's Silvertown factory were among the sequences featured in "Forming of Metals," the Shell Film Unit production which was awarded the Grand Prix in a competition for short films during the recent World Film Festival at the Brussels Exhibition. The Venesta factory also earned the added distinction of appearing on the B.B.C. television programme "Picture Parade," when an excerpt of the film was shown to viewers.

Photographed in colour, and having a running time of 25 minutes, the film deals with all forms of metalworking other than cutting. It is available for presentation to student engineers and trainees, etc. Shots for the Venesta sequence were made last year when a film unit from Shell visited Silvertown, following the selection of the factory as an outstanding example of automation applied to impact extrusion of collapsible tubes, and as an illustration of modern methods of foil rolling.

### New Dundee Offices

To mark the official opening of the new Dundee sales branch office of **British Insulated Callender's Cables Ltd.**, at 2 South Ward Road, Dundee, a special exhibition of some of the company's products was held last week. The items shown included wiring systems, mineral insulated cables and accessories, rising main boxes and capacitors for power factor correction. The branch is under the management of Mr. R. A. Arnold, who has represented the company in Dundee for 15 years.

### Harwell Reactor School

It is understood that the next standard course at the Harwell Reactor School on which places are available starts on

November 10 this year and ends on March 6, 1959. The fee for the course is £250, exclusive of accommodation. Applications will be considered from overseas as well as the United Kingdom, and this will be the seventeenth standard course at the school, where the 1,000 students who have attended to date include 231 from 31 other countries.

Application forms and further details can be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

### Change of Name

As from the first day of this month, **Honeywell-Brown Ltd.** changed its name to **Honeywell Controls Ltd.** On the same date, all head office departments and the London branch office moved from Perivale to a new building at Ruislip Road East, Greenford, Middx.

The new name identifies the company with its range of products—instrumentation heating and air conditioning controls, micro switches—and lines up with the names adopted by most overseas affiliates of the company. The new building at Greenford, which incorporates many modern aids to operating efficiency, puts all marketing functions—sales and service engineering, training school, export activities—and their executive direction, under one roof.

### Area Representatives

It has been announced by **Sheepbridge Alloy Castings Ltd.** that **E. H. Benet** and **Son**, of 124 Seymour Place, London, W.1, have been appointed their Southern Area representatives.

### Non-Destructive Testing

Last in a series of three booklets published by the **British Welding Research Association** forming their handbook of non-destructive testing is the "Memorandum on Non-Destructive Methods for the Examination of Welds," which replaces an earlier memorandum published in 1952.

The main chapter headings in this memorandum are: radiographic methods, ultrasonic and other acoustical methods, magnetic methods, penetrant methods, gas leak method, the proof test or overload test, and semi-destructive methods. The memorandum covers 80 pages, is priced at 7s. 6d. and may be obtained from the publications department of the association.

### Change of Address

Larger premises have been taken over by **The English Electric Company Limited** for their Birmingham branch, which is now situated at Pitmaston, Moseley, Birmingham, 13. The domestic appliance sales section is also located in the new premises, but the appliance service depot remains at 175 Tennant Street, Birmingham, 15.

### Foundry Equipment for South Africa

Advice has been received by the Export Services Branch of the Board of Trade that Mr. J. R. Mitchell, a director of **S.A. Furnace and Engineering Co. (Pty.) Ltd.**, 806 Elizabeth House, Johannesburg, South Africa, has told the U.K. Trade Commissioner in that city that he

is very interested in obtaining U.K. agencies for foundry equipment. He is particularly interested in compacting machines, sifters and vibrators. British manufacturers are invited to contact Mr. Mitchell direct.

#### Enquiry for Tin Ingots

Tenders are called for by the Ports, Railways and Transport Department, Lourenco Marques, Portuguese East Africa, for 15,000 kg. tin ingots, 99.95 per cent. The closing date for receipt of tenders is August 11, 1958. A photocopy of the tender announcement only (in Portuguese) may be obtained from the Export Services Branch, the Board of Trade, Lacon House, Theobalds Road, London, W.C.1, on payment of 1s. 0d. (Ref. ESB/14558/58).

#### Nickel Problem in Japan

Recent news from Tokyo states that the Nippon Mining Company, a leading nickel refinery in Japan, has suggested that local nickel producers suspend production of both metal and ferro-nickel for six months to tide over the current recession on the nickel market here. Leaders of the industry are to discuss the problem at an emergency conference to be held shortly. The company said nickel production in Japan had already been curtailed by between 40 and 60 per cent because exports of both items, which account for half the production, had dropped sharply—especially to European markets.

Output in April thus totalled 490 tons of metal nickel and 200 of ferro-nickel, while no new export contract for the products has been concluded since last autumn, the company added. Stocks at the end of April rose to 2,100 tons of metal nickel and 1,600 tons of ferro-nickel against normal levels of 1,000 and 400 tons respectively.

Japanese nickel refineries had hoped to gain a new export market in mainland China, but their hope was shattered by the recent rupture of trade relations. The refineries have been withholding purchases of nickel ore from New Caledonia—the only supplier to Japan—in view of the increase in stocks and dwindling exports. To cope with the situation, producers have made every effort to seek lower prices of nickel ore, and succeeded in concluding contracts with New Caledonian shippers to buy nearly 20,000 tons at 48 cents per lb. f.o.b. New Caledonia for 3.2 per cent ore. However, these contracts were held up by the New Caledonian Government, who did not approve them because of the low price.

Japan must buy ore from New Caledonia as she has no other source of supply. The nickel refining industry has, therefore, started top level discussions on the import of ore, and the Japanese Mining Association is to send a mission to New Caledonia for direct negotiations with the Government and shippers.

#### Laboratory Extension

Costing some £15,000, a laboratory extension is in the course of construction for **English Metal Powder Company** at West Drayton, Middlesex. Covering 2,800 ft<sup>2</sup>, it will be particularly concerned with giving research assistance to users of the company's products, especially in the paint and lightweight concrete industry. The range of equipment which is to be installed will, however, broaden

the scope of the laboratory to enable progress on many subjects relating to the use of aluminium powder and paste.

The laboratory will contain all the necessary equipment for the testing of aluminium stove enamels or any other resin-based aluminium paint containing aluminium paste, and there will be a special newly-designed gas reaction velocity measuring apparatus for the testing of aluminium powders. Further, a sea-water testing tank will provide facilities to study the influence of sea water on aluminium paste-based paints.

#### Aluminium Futures Market

Interest is being shown by some members of the London Metal Exchange in the possibility of forming a futures contract market in aluminium. A notice displayed on the notice board of the Exchange last week asked members who had ideas or proposals to make about such a scheme to communicate in writing to the secretary.

However, producers are not too enthusiastic in every case, mainly because they do not favour a price which varies from day to day as does, for example, the price of copper. They would, in many cases, prefer stability of price. Another point which is mentioned against the scheme is that some contracts differ and that, in some cases, governments have rights of first refusal.

The idea of a futures contract has been mooted on several occasions during the past two years. There has never been a market in aluminium on the London Metal Exchange, and at the moment dealings in aluminium are handled by private arrangements between producers and consumers on extended contracts.

Mr. P. G. Smith, the chairman of the committee of the London Metal Exchange, commented last year on such proposals by saying that no approach had yet been made to the committee, but that the committee would give sympathetic consideration to any proposals which may be made. It had to be made clear, however, that the committee were not prepared to consider opening a market unless it was assured that a sufficient volume of business would be enacted, to ensure that the prices quoted would be a true representation of the aluminium price of each day. This made it essential that sufficient producers and consumers should back the proposals and should be prepared to deal through the market if it were opened. He gave the unsuccessful pre-war attempt to open a market in silver as a warning example.

#### A 50th Anniversary

During the past 50 years there has been a development of scientific knowledge unparalleled in the history of the world. Research is of fundamental importance to scientific development and this year the **Brown-Firth Research Laboratories**, one of the first industrial research organizations in the world, celebrate their golden jubilee, having been founded as a separate organization in the year 1908.

The original laboratory was housed in part of what is now the electric melting department of the firm, and had a staff of three. To-day, a huge building, facing two streets in Sheffield, provides the Brown-Firth organization with facilities for almost every type of research. The laboratories carry out not only research but also regular examination of works' products. There is hardly a works process, be it melting, casting, hot work-

ing, heat-treatment, machining, or other procedure, where the help of the laboratories has not been sought, and where the works has failed to benefit by the advice given, often after considerable experiments have had to be carried out.

#### Aluminium in Packaging

Those taking part in the Symposium, "Aluminium in Packaging," held in London last week, were entertained to luncheon at the Savoy Hotel by the Council of the **Aluminium Development Association**, which had sponsored the Symposium. The guest of honour at the luncheon was Mr. W. J. Taylor, C.B.E., M.P., Parliamentary Secretary to the Ministry of Supply.

The President of the association, Mr. S. E. Clotworthy, B.Sc., M.I.E.E., in welcoming the guests, made brief references to the scope and activities of the association, amongst which were the holding of one or more Symposia, each to survey achievements and prospects of aluminium in specific industries.

In replying to the President's remarks, Mr. W. J. Taylor drew attention to the wide range of products to which aluminium was applied as a packaging, and commented on the fact that his Ministry was itself a large user of aluminium. He concluded by affirming the interest of the Government and his Ministry in the work and progress of the association.

At the technical sessions of the Symposium more than 300 delegates from the packaging and aluminium industries discussed a total of eight Papers on the various applications of aluminium to the field of packaging. A small but representative exhibition aroused considerable interest.

#### Aluminium and Copper Exports

There is a control over the export of certain aluminium, copper, and iron and steel goods to ensure that scrap metal is retained in the United Kingdom. In this connection, the Board of Trade announce that the Open General Licences which authorize the export of certain aluminium, copper, and iron and steel goods valued at more than £240, £350 (and of certain copper alloy goods valued at £240 per ton) and £35 per ton respectively, are being revoked and replaced by new Open General Licences which lower this value limit as follows:—

Aluminium goods to £220 per ton; copper goods to £300 per ton and the value of any alloy mainly of copper in any goods to £200 per ton; iron and steel goods to £25 per ton.

The goods are those specified in Group 6(2) of the First Schedule to the Export of Goods (Control) (Consolidation) Order, 1958. Enquiries about these licences should be made to the Export Licensing Branch, Gavrelle House, Bunhill Row, London, E.C.1.

Copies of the Open General Licences (price 3d. each, by post 5d. each) may be obtained from H.M. Stationery Office, Kingsway, London, W.C.2, and branches.

#### International Meeting

Delegates from the copper and copper alloy fabricating industries of 13 Western European countries were present when the General Assembly of the **International Wrought Non-Ferrous Metals Council** met in Venice on Monday last, under the chairmanship of Mr. C. A. Jacobsson, of Sweden. The trend of home and export business was discussed, and most members reported that production of copper

and copper alloy semi-finished products was being maintained at a good level.

The meeting reviewed the activities of the Council during the past year, the fifth since its foundation, and particularly commended the work of its sub-committees dealing with productivity, mechanical handling, accident prevention, development and costing methods. International co-operation on these and similar subjects is proving to be of great benefit to the industry.

#### U.K. Metal Stocks

Stocks of refined tin in London Metal Exchange official warehouses at the end of last week totalled 19,101 tons, comprising London 5,887, Liverpool 11,999, and Hull 1,215 tons. Copper stocks totalled 14,882 tons, and comprised London 9,224, Liverpool 5,358, Birmingham 75, Manchester 50, and Swansea 175 tons.

#### An Educational Trust

It is announced by the British Overseas Mining Association that a B.O.M.A. Educational Trust has been established by the association to provide scholarships, tenable at mining schools and universities in the United Kingdom for courses in mining engineering and related subjects. It is envisaged that up to ten such scholarships, the value of which will vary up to a maximum of £400 per annum, will be made available each year. The scholarships will not be subject to means tests.

In addition, it is proposed to offer each year one, or possibly two, awards of £500 per annum for a two years' conversion course in mining engineering or a related subject at the Royal School of Mines, Imperial College, University of London, to men who have recently graduated in some other branch of engineering.

Further information regarding this scheme may be obtained from the secretary of the association at 8 Great Winchester Street, London, E.C.2.

#### New London Office

It is understood that the London office of Steele and Cowlishaw Ltd. has moved to Westwood House, Swallow Street, Piccadilly, London, W.1, with the telephone number of Regent 8301. The previous office at High Holborn is now closed.

#### New President

Members of the British Acetylene Association recently elected as their President for the ensuing year **Mr. E. Seymour-Semper**, M.I.Mech.E., F.R.S.A., M.S.E., director of Hancock and Company (Engineers) Ltd., oxygen cutting machine manufacturers.

Mr. Seymour-Semper's interest in welding started in 1921 when a student at Sheffield University. He subsequently joined the British Oxygen Company Ltd., and during the second world war was appointed adviser on gas welding and cutting to the Ministry of Supply. Shortly after the war he joined his present company and has been a director for the past ten years.

#### Australian Aluminium for Malaya

News from Singapore is to the effect that Australia will soon be in a position to supply aluminium to Malaya. In stating this, the Australian Trade Commissioner in Singapore said that Australia's aluminium industry had made tremendous progress in recent years. The recent discovery of huge bauxite deposits in

North Queensland would not only enable Australia to produce sufficient aluminium for her own expanding requirements, but would allow substantial exports, he said.

Malaya imports half her aluminium from Britain, and the rest from Belgium, West Germany, Austria and Japan. Last year Malaya imported 2,636 tons of aluminium products, worth more than seven million Malayan dollars.

#### Solders and Fluxes

A revised edition of their technical booklet entitled "Solders and Fluxes for Cable Jointing" has just been published by Fry's Metal Foundries Ltd. This

booklet, which covers 28 pages, discusses the metallurgical aspects of jointing conductor cables and is divided into three sections as follows: (1) jointing of copper cored cables, (2) jointing of aluminium cored cables, and (3) jointing of aluminium sheathed cables.

The main aim of the booklet is to describe the function of both the metal and the flux in cable jointing, and thus give a better understanding of the factors which make for ease and speed of working, as well as for soundness and permanence of the installation. A number of illustrations and diagrams are included, and copies of the booklet may be obtained on application to the firm.

## Scrap Metal Merchants Annual Meeting

ON Wednesday of last week, the annual general meeting of the National Association of Non-Ferrous Scrap Metal Merchants was held at Grosvenor House, Park Lane, London, under the chairmanship of **Mr. M. C. Elton**, the President. In his report for the year, the President said that the Council had held the usual six meetings since last December, all of them being in London. He made reference to the fourth successive course of lectures on the technical aspects of the industry, which had commenced at the City of London College, and expressed thanks to all those who were associated with the organization of the lectures, and also the lecturers. In regard to recruitment, he said it was encouraging to note that a number of members had engaged applicants for employment as a result of particulars concerning prospective entrants to the industry published in the association's Bulletin. Other subjects touched upon in the report included the following: free trade in scrap; remelted zinc; manganese bronze; U.S. Classifications and the B.I.R.; the Clean Air Act; Revision of Wallasey Corporation Bill; L.E.B. disposals; Coal Board disposal methods; R.O.F.'s insistence on rail transport; the financial statement, and in his conclusion the President thanked the members of the Council, and the secretary and his staff, for their support and help.

During the discussion on the President's Report, **Mr. A. E. Malley** asked for more information on the negotiations regarding changes in export arrangements and members concerned in the negotiations. In his reply, the President stated that the policy of the association had been to press for the removal of export restrictions. Negotiations were carried on through the Joint Non-Ferrous Scrap Committee, but so far the committee had not been able to convince the Government of the need for freeing exports, but the association would continue to press for action in this matter.

Mr. Malley then asked what items of scrap the Council had in mind in connection with the question of exporting certain types of scrap from this country against the import of scrap from abroad. The President replied that this particular point arose in connection with surplus Q.F. cases, which, it was suggested, might be exported against the import of copper wire. Mr. Malley, pressing for further information as to whether the Council would be informed before any export licences were granted in future, and the extent to which the Board of Trade relied on the advice and suggestions of the association, was told that the association

had persistently stressed that no export regulations should be changed without consulting the association.

On the subject of the Clean Air Act, Mr. Malley said he was apprehensive that with the coming into force of this Act, and with suitable technical facilities only economical for large-scale operations, that it would not be sound business for anybody to indulge in heavy capital expenditure with the possibility of export licences for scrap cable perhaps being granted at a later date. He was anxious that before any such licences were granted not only should the association be consulted, but the material involved should first be offered to all members of the association. The President pointed out, however, that the price of scrap cable might have hardened as the result of some dealers buying with the possibility of a rise in the copper price. Any granting of individual export licences without first consulting the association was a fault which lay with the B.O.T., who had promised to notify the association whenever they were open to receive export licences for any particular grade of scrap.

Protesting at the suggestion in Mr. Malley's remarks that the Council should be given powers to interfere with the freedom of action of members, **Mr. Charles Bond** thought any member should be free to approach any Ministry with a suggestion.

On the proposals to amend two of the rules, a good deal of discussion ensued, and it was finally agreed that not more than two representatives of a company or group would serve on the Council at the same time. The second proposed amendment was lost.

**Mr. R. O. Barnett** (Arthur E. Milner (Metals) Ltd.) was elected President for the ensuing year. The election of six members to fill vacancies on the Council resulted in the election of **Mr. M. C. Elton**, **Mr. G. B. Garnham**, **Mr. Gillott**, **Mr. L. Lazarus**, **Mr. S. W. Platt**, and **Mr. T. R. White**. **Mr. A. C. W. Wood** was unanimously re-elected hon. treasurer, and **Mr. Jacques Lion** as vice-president.

At the annual luncheon which followed the meeting, the new President occupied the chair, supported by members of the Council and guests, who included **Mr. W. J. Taylor**, C.B.E., D.L., J.P., M.P., Parliamentary Secretary, Ministry of Supply. After the "Loyal Toast" had been honoured, Mr. Taylor proposed the toast of "The Association," and reply was made by the President. **Mr. M. C. Elton**, past-president, proposed the toast of "The Guests," and response was made by **Mr. L. H. Tarring**.

## Metal Market News

THE metal markets made a cheerful start last week, in spite of the fact that the week-end news about the strike troubles in London was no better and the docks virtually at a standstill. Activity continued in copper on the Commodity Exchange in New York, and there is really no indication that this big bull movement is coming to an end. It has certainly had a remarkable run, and the rising tide of values has persisted much longer than most people expected. On the whole, Wall Street has put up a very good show and it is now fairly generally accepted that the worst of the recession in the United States is over, at any rate for the present. On the other hand, a recent forecast regarding employment suggests that the outlook for the winter is not very favourable, and that there is every likelihood of a marked increase over the present figure. There certainly seems to be much more optimism in America now, and it must be hoped that this is justified by developments during the coming months. So far as the U.K. is concerned, the most discouraging aspect of the situation is, of course, the persistent unrest on the labour front, but even so there are signs that moderate counsels are in the ascendant. If this means, as it may well do, that there is a realization of the fact that ever-increasing wage demands merely provide fuel for the inflationary fire, without in the long run benefiting anybody, then there are grounds for moderate optimism. So far this year the U.K. export business has been very well maintained, but there have been warnings recently that our prices are hitting the ceiling.

After closing with a firm tone on the previous Friday, copper opened with a strong tendency on Monday last week and, in the course of trading, £190 was paid for the three months' position, but the turnover was moderate. A reduction of no less than 855 tons in the L.M.E. stocks to 15,622 tons came as something of a surprise, although the tendency has of late been downwards. Further encouragement to the bulls was afforded by an increase in the Belgian price to 26.25 francs per kilo. A further lift was afforded by a much more important item of news, which came in the shape of a report from the United States of suggested stockpiling on the grand scale. This was no less than a projected plan for the U.S. Government to take over some 175,000 short tons of copper on the basis of a price of 27½ cents per lb. The expenditure involved would be gigantic, no less than about \$90 million, and would, of course, mean that at a time when, broadly speaking, stockpiling as a national plan is being abandoned in the United States, the taxpayer would be called upon to finance this huge

operation. That the London market was impressed was shown by the reaction to the news, which on Tuesday lifted values by £3 10s. 0d.

Strictly speaking, the stockpile purchase plan was responsible for only part of this advance for news that the custom smelters had added a further 25 points to their quotation, bringing it level with the producers at 25 cents, was an additional bull point. In all, including a very active Kerb market, the turnover was 6,100 tons on Tuesday alone. The Board of Trade offered to sell 2,000 tons of copper to help consumers affected by the hold-up at the docks. Little change was seen in zinc and lead, although the former eased slightly early in the week. Business in tin was about normal, but the turnover, it was understood, included Russian metal. Activity on the New York Commodity Exchange in copper continued unchecked.

### New York

Continued strength in custom smelter copper featured the market during the past week. Brisk fabrication demand and scarce supplies of electrolytic, reflecting a dearth of new scrap intake, combined to raise the custom smelter price another half cent to 25 cents, or the level of the producer price. Leading trade sources said fabricator buying was partly in anticipation of the copper tariff of 1.7 cents a lb. to be imposed on July 1, and represented a desire to pick up the cheaper custom smelter copper as long as it was available.

Producers reported little significant change in their sales. In fact, one leading producer source said copper sales were beginning to show a slight falling-off from the pace of the past few weeks, reflecting the approaching summer vacation period. The non-ferrous mining industry generally concentrated a major part of its attention on Washington, where hearings began by the Minerals Sub-Committee of the Senate Interior Committee on the Administration's subsidy payments plan for copper, lead, zinc, fluorspar and tungsten. The trade was aroused by reports that the Administration might again institute copper stockpiling, and the Secretary of the Interior, Fred A. Seaton, was expected to present the Administration's views when he testifies before the Senate Sub-Committee later this week.

Meanwhile, testimony by the copper and brass industry before the committee showed opposition to the Administration subsidy plan. Mr. T. E. Veltfort, managing director of the Copper and Brass Research Association, reiterated the association's firm opposition to the plan. However, spokesmen for the tungsten industry

supported the subsidy programme as embodied in the Bill.

In the lead sector, slow demand and excess stocks, intensified by competition from cheaper imported lead, forced a further half cent price drop to 11 cents per lb. Domestic lead, after some betterment in demand on the heels of the price decline, reverted to its previous slow trading.

Prime western zinc was fair over the week, helped by some demand from galvanizers. However, demand for special high-grade metal used in die-casting, especially for the automobile industry, continued depressed. Zinc held at 10 cents per lb. East St. Louis. Officials of the State Department were reported to have met with members of the U.S. lead and zinc mining industry to discuss the proposed formation of an international study group for lead/zinc problems. The study group would include representatives of Governments of countries producing the metals and economists and industry advisory participants from each such nation. Officials of the U.S. companies expressed interest in the study group but said details had to be worked out.

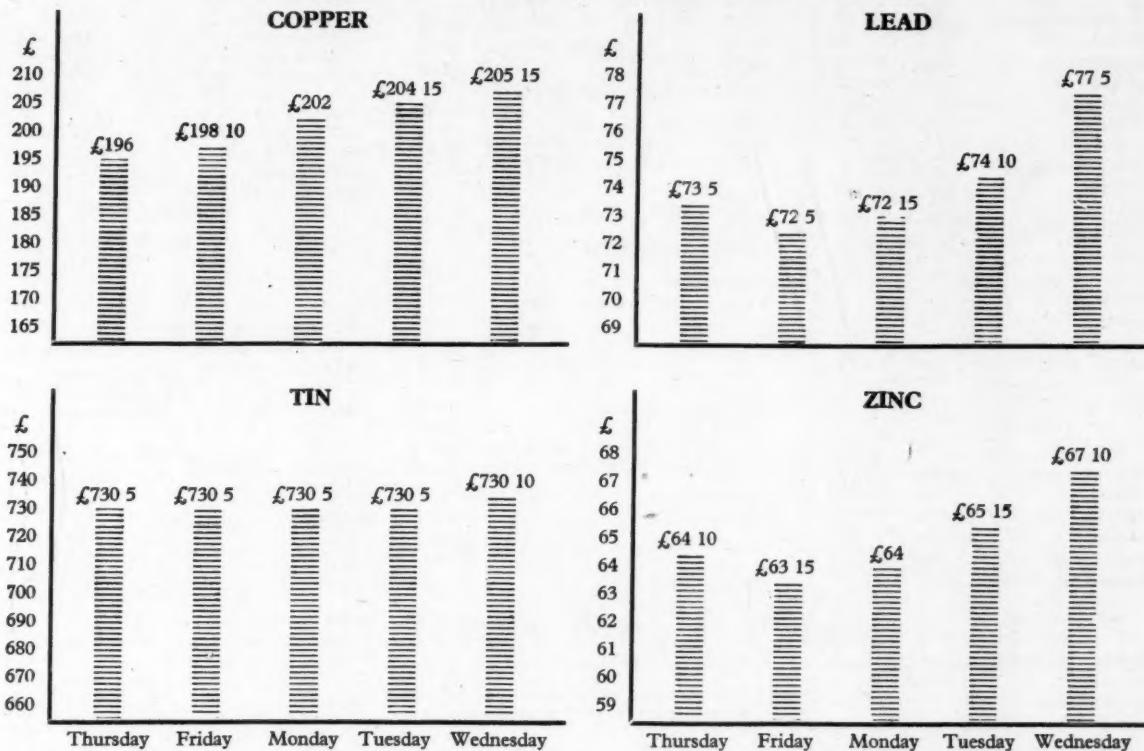
### Birmingham

The metal-using industries in the Midlands maintain fairly active conditions and, on the whole, the position bears favourable comparison with other industrial areas. The chief reason for this is that the area does not rely on one industry for its prosperity, but on a wide variety of light, medium and heavy trades. Even so, the prosperity or otherwise of the motor trade affects numerous smaller industries linked with it, and the fact that the principal motor car manufacturers have substantial export business is of vital importance to the area as a whole. Electrical engineering firms are busy on both home and export trade. There is, however, less activity in the works producing non-ferrous pressings and castings for the building trade. Exporters of such products are finding competition increasingly keen.

It would appear that many users of iron and steel are reducing stocks rather than place fresh contracts, and this is reflected in the latest figures of production, which again show a downward trend. Apart from heavy steel plates, where the position is still tight, reasonably early delivery can be obtained of basic materials. There is a surplus of pig iron, due to the falling-off in trade in light castings as well as to the fact that less basic iron is required for steelmaking. The activity in the motor trade is largely responsible for the continued demand for steel sheets. On the other hand, trade in small bars and sections is only moderate, and the re-rolling mills are working short time.

## METAL PRICE CHANGES

LONDON METAL EXCHANGE, Thursday 12 June 1958 to Wednesday 18 June 1958



## OVERSEAS PRICES

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium fr/kg ≈ £/ton	Canada c/lb ≈ £/ton	France fr/kg ≈ £/ton	Italy lire/kg ≈ £/ton	Switzerland fr/kg ≈ £/ton	United States c/lb ≈ £/ton
<b>Aluminium</b>		22.50 185 17 6	210 182 15	375 217 10		26.10 208 17 6
<b>Antimony 99.0</b>			195 169 12 6	430 249 10		29.00 232 0
<b>Cadmium</b>			1,500 1,305 0			155.00 1,240 0
<b>Copper</b> Crude Wire bars 99.9 Electrolytic	27.50 201 0	24.00 198 5	247 214 17 6	385 223 7 6	2.30 192 7 6	25.00 200 0
<b>Lead</b>		10.50 86 15	110 95 15	178 103 5	.93 77 15	11.00 88 0
<b>Magnesium</b>						
<b>Nickel</b>		71.50 590 10	1,205 1,048 7 6	1,300 754 0	7.80 652 5	74.00 592 0
<b>Tin</b>	103.00 753 0		910 791 15	1,400 812 0	8.60 719 2 6	94.75 758 0
<b>Zinc</b> Prime western High grade 99.95 High grade 99.99 Thermic Electrolytic		10.00 82 12 6 10.60 87 10 0 11.00 90 5	107.12 93 2 6 115.12 100 2 6	157 91 0	.82 68 10	11.25 90 0

## NON-FERROUS METAL PRICES

(All prices quoted are those available at 12 noon 18/6/58)

### PRIMARY METALS

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99.6%	"	197	0	0
Antimony Metal 99%	"	190	0	0
Antimony Oxide	"	180	0	0
Antimony Sulphide Lump	"	190	0	0
Antimony Sulphide Black Powder	"	205	0	0
Arsenic	"	400	0	0
Bismuth 99.95%	lb.	16	0	
Cadmium 99.9%	"	10	0	
Calcium	"	2	0	0
Cerium 99%	"	16	0	0
Chromium	"	6	11	
Cobalt	"	16	0	
Columbite per unit	"	—		
Copper H.C. Electro.	ton	205	15	0
Fire Refined 99.70%	"	204	0	0
Fire Refined 99.50%	"	203	0	0
Copper Sulphate	"	70	0	0
Germanium	grm.	—		
Gold	oz.	12	9	5
Indium	"	10	0	
Iridium	"	24	0	0
Lanthanum	grm.	15	0	
Lead English	ton	77	5	0
Magnesium Ingots	lb.	2	5½	
Notched Bar	"	2	10½	
Powder Grade 4	"	6	3	
Alloy Ingot, A8 or AZ91	"	2	8	
Manganese Metal	ton	300	0	0
Mercury	flask	76	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.	5	5	
F. Ingot	"	5	6	
Osmium	oz.	nom.		
Osmiridium	"	nom.		
Palladium	"	6	10	0
Platinum	"	25	0	0
Rhodium	"	40	0	0
Ruthenium	"	16	0	0
Selenium	lb.	nom.		
Silicon 98%	ton	nom.		
Silver Spot Bars	oz.	6	3½	
Tellurium	lb.	15	0	
Tin	ton	730	10	0
<b>*Zinc</b>				
Electrolytic	ton	—		
Min 99.99%	"	—		
Virgin Min 98%	"	67	12	6
Dust 95.97%	"	104	0	0
Dust 98.99%	"	110	0	0
Granulated 99.4%	"	92	12	6
Granulated 99.99%	"	105	7	6

\*Duty and Carriage to customers' works for buyers' account.

### INGOT METALS

Aluminium Alloy (Virgin)	£	s.	d.	
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	"	202	0	0
B.S. 1490 L.M.7	"	216	0	0
B.S. 1490 L.M.8	"	203	0	0
B.S. 1490 L.M.9	"	203	0	0
B.S. 1490 L.M.10	"	221	0	0
B.S. 1490 L.M.11	"	215	0	0
B.S. 1490 L.M.12	"	223	0	0
B.S. 1490 L.M.13	"	216	0	0
B.S. 1490 L.M.14	"	224	0	0
B.S. 1490 L.M.15	"	210	0	0
B.S. 1490 L.M.16	"	206	0	0
B.S. 1490 L.M.18	"	203	0	0
B.S. 1490 L.M.22	"	210	0	0

Aluminium Alloy (Secondary)		£	s.	d.
B.S. 1490 L.M.1	ton	151	0	0
B.S. 1490 L.M.2	"	158	0	0
B.S. 1490 L.M.4	"	179	0	0
B.S. 1490 L.M.6	"	195	0	0

†Average selling prices for April

Aluminium Bronze		£	s.	d.
BSS 1400 AB.1	ton	203	0	0
BSS 1400 AB.2	"	—		

Brass		£	s.	d.
BSS 1400-B3 65/35	"	—		
BSS 249	"	139	0	0
BSS 1400-B6 85/15	"	—		

Gunmetal		£	s.	d.
R.C.H. 3/4% ton	ton	—		
(85/5/5)	"	168	0	0
(86/7/5/2)	"	179	0	0
(88/10/2/1)	"	229	0	0
(88/10/2/½)	"	238	0	0

Manganese Bronze		£	s.	d.
BSS 1400 HTB1	"	170	0	0
BSS 1400 HTB2	"	—		
BSS 1400 HTB3	"	180	0	0

Nickel Silver		£	s.	d.
Casting Quality	12%	"	nom.	
"	16%	"	nom.	
"	18%	"	nom.	

Phosphor Bronze		£	s.	d.
2B8 guaranteed A.I.D.	released	"	252	0

Phosphor Copper		£	s.	d.
10%	"	232	0	0
15%	"	240	0	0

\*Average prices for the last week-end.

Phosphor Tin		£	s.	d.
5%	ton	—		

Silicon Bronze		£	s.	d.
BSS 1400-SB1	"	—		

Solder, soft, BSS 219		£	s.	d.
Grade C Tinmans	"	345	9	0
Grade D Plumbers	"	280	0	0
Grade M	"	378	6	0

Solder, Brazing, BSS 1845		£	s.	d.
Type 8 (Granulated)	lb.	—		
Type 9	"	—		

Zinc Alloys		£	s.	d.
Mazak III	ton	98	12	6
Mazak V	"	102	12	6
Kayem	"	108	12	6
Kayem II	"	114	12	6
Sodium-Zinc	lb.	2	5½	

SEMI-FABRICATED PRODUCTS		£	s.	d.
Prices of all semi-fabricated products vary according to dimensions and quantities. The following are the basis prices for certain specific products.				
Aluminium	£	s.	d.	
Sheet 10 S.W.G. lb.	2	8		
Sheet 18 S.W.G. "	2	10		
Sheet 24 S.W.G. "	3	1		
Strip 10 S.W.G. "	2	8		
Strip 18 S.W.G. "	2	9		
Strip 24 S.W.G. "	2	10½		
Circles 22 S.W.G. "	3	2		
Circles 18 S.W.G. "	3	1		
Circles 12 S.W.G. "	3	0		
Plate as rolled	"	2	7½	
Sections	"	3	1½	
Wire 10 S.W.G. "	2	11		
Tubes 1 in. o.d. 16 S.W.G. "	4	0		

Aluminium Alloys		£	s.	d.
BS1470. HS10W. lb.				
Sheet 10 S.W.G. "	3	0		
Sheet 18 S.W.G. "	3	3		
Sheet 24 S.W.G. "	3	10½		
Strip 10 S.W.G. "	3	9		
Strip 18 S.W.G. "	3	4		
Strip 24 S.W.G. "	3	10		

BS1474. HP30M.		£	s.	d.
Plate as rolled	"	2	10½	

BS1470. HC15WP.		£	s.	d.
Sheet 10 S.W.G. lb.	3	6½		
Sheet 18 S.W.G. "	4	0		
Sheet 24 S.W.G. "	4	10½		
Strip 10 S.W.G. "	3	9		
Strip 18 S.W.G. "	4	0		
Strip 24 S.W.G. "	4	8		

BS1474. HPC15WP.		£	s.	d.
Plate heat treated	"	3	5½	

BS1475. HG10W.		£	s.	d.
Wire 10 S.W.G. "	3	9½		

BS1471. HT10WP.		£	s.	d.
Tubes 1 in. o.d. 16 S.W.G. "	4	11		

BS1476. HE10WP.		£	s.	d.
Sections	"	3	1	

Beryllium Copper		£	s.	d.
Strip	"	1	4	11
Rod	"	1	1	6
Wire	"	1	4	9

Brass Tubes		£	s.	d.

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## Financial News

### Metal Statistics

Detailed figures of the consumption and output of non-ferrous metals for the month of April, 1958, have been issued by the British Bureau of Non-Ferrous Metal Statistics, as follow in long tons:—

COPPER	Gross Copper Weight Content	
Wire	25,650	25,304
Rods, bars and sections	11,685	7,659
Sheet, strips and plate	12,460	9,925
Tubes	7,363	6,731
Castings and miscellaneous	6,666	—
Sulphate	1,694	—
	65,518	55,506

Of which:

Consumption of Virgin Copper	43,784
Consumption of Copper and Alloy Scrap (Copper Content)	11,722

### ZINC

Galvanizing	7,380
Brass	8,173
Rolled Zinc	2,177
Zinc Oxide	2,112
Zinc Die-casting alloy	3,587
Zinc Dust	691
Miscellaneous Uses	864

Total, All Trades	24,984
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Of which:

High purity 99.99 per cent	3,957
Electrolytic and high grade 99.95 per cent	4,744
Prime Western, G.O.B. and de-based	9,378
Remelted	493
Scrap Brass and other Cu alloys	3,811
Scrap Zinc, alloys and residues	2,336

### ANTIMONY

Batteries	111
Other Antimonial Lead	54
Bearings	32
Oxides—for White Pigments	97
Oxides—other	71
Miscellaneous Uses	32
Sulphides	8
	—
Total Consumption	405

### Antimony in Scrap

For Antimonial Lead	277
For Other Uses	16
	—
Total Consumption	293

### LEAD

Cables	7,899
Batteries	2,561
Battery Oxides	2,180
Tetra Ethyl Lead	1,499
Other Oxides and Compounds	1,786
White Lead	563
Shot	326
Sheet and Pipe	5,194
Foil and Collapsible Tubes	324
Other Rolled and Extruded	468
Solder	1,039
Alloys	1,385
Miscellaneous Uses	1,006
	—
Total	26,230

### CADMIUM

Plating Anodes	40.00
Plating Salts	6.00
Alloys: Cadmium Copper	3.35
Alloys: Other	2.65
Batteries: Alkaline	5.30
Batteries: Dry	0.25
Solder	3.00
Colours	18.00
Miscellaneous Uses	1.45
	—
Total Consumption	80.00

### TIN

Tinplate	915
Tinning:	—
Copper Wire	36
Steel Wire	7
All other	58
Solder	108
Alloys	467
Foil and Collapsible Tubes, etc.	48
Tin Compounds and Salts	76
Miscellaneous Uses	1
	—
Total Consumption	1,725

## Scrap Metal Prices

Merchants' average buying prices delivered, per ton, 17/6/58.

	Aluminium	Gunmetal	
New Cuttings	140	Gear Wheels	165
Old Rolled	114	Admiralty	165
Segregated Turnings	90	Commercial	140
	—	Turnings	135
Brass		Lead	
Cuttings	125	Scrap	63
Rod Ends	122		
Heavy Yellow	107		
Light	102		
Rolled	117		
Collected Scrap	104		
Turnings	116		
Copper		Nickel	
Wire	173	Cuttings	—
Firebox, cut up	173	Anodes	475
Heavy	165		
Light	160		
Cuttings	173		
Turnings	158		
Brazier	138		

The latest available scrap prices quoted on foreign markets are as follow. (The figures in brackets give the English equivalents in £1 per ton):—

West Germany (D-marks per 100 kilos):	Italy (lire per kilo):
Used copper wire	Aluminium soft sheet
(£169.12.6) 195	clippings (new) .. (£191.10.0) 330
Heavy copper	(£169.12.6) 195
(£143.10.0) 165	Aluminium copper alloy (£107.7.6) 185
Light copper	Lead, soft, first quality (£84.2.6) 145
(£108.15.0) 125	Lead, battery plates .. (£49.7.6) 85
Heavy brass	Copper, first grade .. (£182.15.0) 315
(£78.7.6) 90	Copper, second grade (£171.2.6) 295
Light brass	Bronze, first quality machinery (£182.15.0) 315
(£61.0.0) 70	
Soft lead scrap	Bronze, commercial gunmetal (£153.15.0) 265
(£36.10.0) 42	Brass, heavy (£130.10.0) 225
Zinc scrap	Brass, light (£119.0.0) 205
(£87.0.0) 100	Brass, bar turnings .. (£127.12.6) 220
Used aluminium unsorted	New zinc sheet clippings (£55.2.6) 95
(£87.0.0) 100	Old zinc (£40.12.6) 70
France (francs per kilo):	
Copper	(£208.17.6) 240
Heavy copper	(£208.17.6) 240
Light brass	(£148.0.0) 170
Zinc castings	(£65.5.0) 75
Tin	(£565.10.0) 650
Aluminium pans (98½ per cent)	(£117.10.0) 135

The particulars of companies recently registered are quoted from the daily register compiled by Jordan and Sons Limited, Company Registration Agents, Chancery Lane, W.C.2.

**Lawton (Heat Treatments) Limited** (601698), 104 Dudley Road East, Oldbury, Birmingham. Registered March 28, 1958. To carry on business of metal workers and general engineers engaged in the treatment of metals, etc. Nominal capital, £5,000 in £1 shares. Directors: Henry W. Lawton and Elisie M. Lawton.

**Allender Limited** (601987), Margaret Street, Ashton-under-Lyne, Lancs. Registered April 1, 1958. Carry on business of metal manufacturers, etc. Nominal capital, £3,000 in £1 shares. Directors: John J. Allender, jnr., and Harold Allender.

**J. D. Haines (Die-Casting) Limited** (602103), Queen's College Chambers, Queen's College, Paradise Street, Birmingham, 1. Registered April 2, 1958. Nominal capital, £1,000 in £1 shares. Directors: John D. Haines, Richard A. Ormerod, Norman W. Hope and John W. Borland.

**Denton's (Metals) Limited** (603724), 77 Portland Place, W.1. Registered April 30, 1958. Nominal capital, £100 in £1 shares. Director: Charles H. Denton.

# THE STOCK EXCHANGE

## The Tendency Of Metal Prices Is Upwards

ISSUED CAPITAL	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 17 JUNE +RISE — FALL	DIV. FOR	DIV. FOR PREV. YEAR	DIV. YIELD	1958		1957	
				LAST FIN. YEAR			HIGH	LOW	HIGH	LOW
£	£			Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation	20/6 —9d.	10	10	9 15 0	21/3	17/9	28/3	18/-
400,000	2/-	Anti-Accrion Metal	1/6	4	8½	5 6 9	1/6	1/3	2/6	1/6
33,639,483	Stk. (£1)	Associated Electrical Industries	48/6xd +9d.	15	15	6 3 9	51/-	47/-	72/3	47/9
1,590,000	1	Birfield Industries	48/6 +1/9	15	15	6 3 9	53/9	46/3	70/-	48/9
3,196,667	1	Birmid Industries	66/3 —1/9	17½	17½	5 5 9	68/-	56/3	80/6	55/9
5,630,344	Stk. (£1)	Birmingham Small Arms	28/- —1½d.	10	8	7 2 9	28/6	23/9	33/-	21/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	15/4½	5	5	6 10 0	15/7½	14/7½	16/-	15/-
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	16/7½	6	6	7 4 3	17/-	16/6	19/-	16/6
500,000	1	Bolton (Thos.) & Sons	26/3	12½	12½	9 10 6	28/9	26/3	30/3	28/9
300,000	1	Ditto Pref. 5%	15/3	5	5	6 11 3	16/-	15/3	16/9	14/3
160,000	1	Booth (James) & Co. Cum. Pref. 7%	19/3	7	7	7 5 6	19/3	19/-	22/3	18/9
9,000,000	Stk. (£1)	British Aluminium Co.	43/- —3d.	12	12	5 11 9	46/6	37/-	72/-	38/3
1,500,000	Stk. (£1)	Ditto Pref. 6%	19/-	6	6	6 6 3	19/3	18/4½	21/6	18/-
15,000,000	Stk. (£1)	British Insulated Callender's Cables	45/6	12½	12½	5 10 0	45/6	38/9	55/-	40/-
17,047,166	Stk. (£1)	British Oxygen Co. Ltd., Ord.	32/6 —6d.	10	10	6 3 0	35/3	29/-	39/-	29/6
600,000	Stk. (5/-)	Canning (W.) & Co.	19/7½ —1½d.	25 +2½C	25	6 7 6	21/-	19/7½	24/6	19/3
60,484	1/-	Carr (Chas.)	1/9 —3d.	25	25	10 0 0	2/3	1/9	3/6	2/1½
150,000	2/-	Case (Alfred) & Co. Ltd.	4/3	25	25	11 16 3	4/9	4/1½	4/6	4/-
555,000	1	Clifford (Chas.) Ltd.	17/6 +3d.	10	10	11 8 6	17/6	16/-	20/6	15/9
45,000	1	Ditto Cum. Pref. 6%	15/10½	6	6	7 11 3	—	—	17/6	16/-
250,000	2/-	Coley Metals	2/9 —1½d.	20	25	14 11 0	4/6	2/9	5/7½	3/9
8,730,596	1	Cons. Zinc Corp.†	47/- +2/9	18½	22½	7 19 6	51/6	42/6	92/6	49/-
1,136,233	1	Davy & United	50/-	15	12½	6 0 0	50/-	45/9	60/6	42/6
2,750,000	5/-	Delta Metal	20/- +1/-	30	17½	7 10 0	21/4½	17/7½	28/6	19/-
4,160,000	Stk. (£1)	Enfield Rolling Mills Ltd.	33/6 +2/-	12½	15B	7 9 3	33/6	24/-	38/6	25/-
750,000	1	Evered & Co.	27/6xcap —9d.	15Z	15	7 5 6	28/3	26/-	52/9	42/-
18,000,000	Stk. (£1)	General Electric Co.	31/6 +3d.	12½	14	7 6 0	38/7½	29/6	59/-	38/-
1,250,000	Stk. (10/-)	General Refractories Ltd.	30/- —1/9	20	17½	6 13 3	33/9	27/3	37/-	26/9
401,240	1	Gibbons (Dudley) Ltd.	65/-	15	15	4 12 3	66/3	64/-	71/-	53/-
750,000	5/-	Glacier Metal Co. Ltd.	6/3 —3d.	11½	11½	9 4 0	6/6	5/7½	8/1½	5/10½
1,750,000	5/-	Glynwed Tubes	13/7½	20	20	7 6 9	13/7½	12/10½	18/-	12/6
5,421,049	10/-	Goodlass Wall & Lead Industries	23/6 +3d.	13½	18Z	5 10 9	23/6	19/3	37/3	28/9
342,195	1	Greenwood & Batley	46/9	17½	17½	7 9 9	46/10½	45/-	50/-	46/-
396,000	5/-	Harrison (B'ham) Ord.	12/7½ +4½d.	*15	*15	5 18 9	12/7½	11/6	16/9	12/4½
150,000	1	Ditto Cum. Pref. 7%	18/9	7	7	7 9 3	19/-	18/9	22/3	18/7½
1,075,167	5/-	Heenan Group	7/3	10	20½	6 18 0	7/7½	6/9	10/4½	6/9
142,045,750	Stk. (£1)	Imperial Chemical Industries	44/3	12Z	10	5 8 6	44/10	36/6	46/6	36/3
33,708,769	Stk. (£1)	Ditto Cum. Pref. 5%	16/1½	5	5	6 4 0	17/1½	16/-	18/6	15/6
14,584,025	**	International Nickel	147 +4½	\$3.75	\$3.75	4 11 6	148½	132½	222	130
430,000	5/-	Jenks (E. P.) Ltd.	8/3	27½	27½	8 6 9	8/3	6/9	18/10½	15/1½
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	16/3	5	5	6 3 0	16/3	15/-	17/-	14/6
3,987,435	1	Ditto Ord.	45/- +1/-	10	9	4 9 0	45/-	37/6	58/9	40/-
600,000	10/-	Keith, Blackman	17/6 +2/6	15	15	8 11 6	17/6	15/-	21/9	15/-
160,000	4/-	London Aluminium	4/1½ +6d.	10	10	9 14 0	4/3	3/-	6/9	3/6
2,400,000	1	London Elec. Wire & Smith's Ord.	44/9 +1/6	12½	12½	5 11 9	44/9	39/9	54/6	41/-
400,000	1	Ditto Pref.	23/3	7½	7½	6 9 0	23/3	22/3	25/3	21/9
765,012	1	McKechnie Brothers Ord.	32/6	15	15	9 4 6	35/-	32/-	48/9	37/6
1,530,024	1	Ditto A Ord.	31/3	15	15	9 12 0	32/6	30/-	47/6	36/-
1,108,268	5/-	Manganese Bronze & Brass	9/6	20	27½	10 10 6	10/6	9/-	21/10½	7/6
50,628	6/-	Ditto (7½% N.C. Pref.)	6/-	7½	7½	7 10 0	6/3	5/9	6/6	5/-
13,098,855	Stk. (£1)	Metal Box	51/6	20½	15M	3 17 9	51/6	41/9	59/-	40/3
415,760	Stk. (2/-)	Metal Traders	7/-	50	50	14 5 9	7/-	6/3	8/-	6/3
160,000	1	Mint (The) Birmingham	20/-	10	10	10 0 0	22/9	20/-	25/-	21/6
80,000	5	Ditto Pref. 6%	81/6	6	6	7 7 6	83/6	81/6	90/6	83/6
3,064,930	Stk. (£1)	Morgan Crucible A	38/6	10	11	5 4 0	40/-	34/-	54/-	35/-
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref.	17/-	5½	5½	6 9 6	17/3	17/-	19/3	16/-
2,200,000	Stk. (£1)	Murex	55/3	20	20	7 4 9	57/6	53/3	79/9	57/-
468,000	5/-	Ratcliffe's (Great Bridge)	8/7½ +4½d.	10	10	5 16 0	8/7½	6/10½	8/-	6/10
234,960	10/-	Sanderson Bros. & Newbold	25/9	20	27½	7 15 3	27/-	25/6	41/-	24/9
1,365,000	Stk. (5/-)	Serck	12/9 +3d.	17½	15	4 11 6	12/9	11/-	18/10½	11/6
600,400	Stk. (£1)	Stone (J.) & Co. (Holdings)	47/6	16	16	6 14 9	47/6	43/9	57/6	43/9
600,000	1	Ditto Cum. Pref. 6½%	19/6	6½	6½	6 13 3	20/9	19/6	21/9	18/9
14,494,862	Stk. (£1)	Tube Investments Ord.	54/9 —1/-	15	15	5 9 6	55/9	48/4½	70/9	50/6
41,000,000	Stk. (£1)	Vickers	28/9 —4½d.	10	10	6 19 3	32/6	28/9	46/-	29/-
750,000	Stk. (£1)	Ditto Pref. 5%	15/-	5	5	6 13 3	15/6	14/9	18/-	14/-
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	21/3	*5	*5	7 4 9 A	23/-	21/3	24/9	20/7½
2,200,000	1	Ward (Thos. W.) Ord.	75/9 +6d.	20	15	5 5 6	76/3	70/9	83/-	64/-
2,666,034	Stk. (£1)	Westinghouse Brake	39/9 +3d.	10	18P	5 0 9	39/9	32/6	85/-	29/1½
225,000	2/-	Wolverhampton Die-Casting	7/1½	25	40	7 0 3	8/-	7/1½	10/1½	7/-
591,000	5/-	Wolverhampton Metal	17/3	27½	27½	7 19 6	17/7½	14/9	22/3	14/9
78,465	2/6	Wright, Bingley & Gell	3/6	20	17½	14 5 9	3/9½	3/3	3/9	2/7½
124,140	1	Ditto Cum. Pref. 6%	11/6	6	6	10 8 9	—	—	12/6	11/3
150,000	1/-	Zinc Alloy Rust Proof	2/10½	40D	33½	9 5 6	3/1½	2/7½	5/-	2/9

\*Dividend paid free of Income Tax. †Incorporating Zinc Corp. & Imperial Smelting. \*\*Shares of no Par Value. \$ and 100% Capitalized Issue. ¶The figures given relate to the issue quoted in the third column. A Calculated on £14 6 gross. M and 10% capitalized issue. Y Calculated on 11½% dividend. ||Adjusted to allow for capitalization issue. E for 15 months. P and 100% capitalized issue, also "rights" issue of 2 new shares at 35/- per share for £3 stock held. D and 50% capitalized issue. Z and 50% capitalized issue. B equivalent to 12½% on existing Ordinary Capital after 100% capitalized issue. 6 And 100% capitalized issue. X Calculated on 17½%. C Paid out of Capital Profits.

